MISSILE DEFENSE AGENCY (MDA)
SMALL BUSINESS INNOVATION RESEARCH PROGRAM (SBIR)

INTRODUCTION

The MDA SBIR program is implemented, administrated and managed by the MDA Office of Small and Disadvantaged Business Utilization (SADBU). The MDA SBIR Program Manager is Frank Rucky. If you have any questions regarding the administration of the MDA SBIR program please call 1-800-WIN-BMDO. Additional information on the MDA SBIR Program can be found on the MDA SBIR home page at http://www.winbmdo.com/. Information regarding the MDA mission and programs can be found at http://www.acq.osd.mil/bmdo.

For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457. For technical questions about the topic, contact the Topic Authors listed under each topic on the http://www.dodsbir.net website before **2 December 2002.**

PHASE I GUIDELINES

MDA intends for Phase I to be only an examination of the merit of the concept or technology that still involves technical risk, with a cost not exceeding $70,000.

Phase I Proposal Submission

Read the DoD front section of this solicitation for detailed instructions on proposal format and program requirements. When you prepare your proposal submission, keep in mind that Phase I should address the feasibility of a solution to the topic. MDA accepts Phase I proposals not exceeding $70,000. The technical period of performance for the Phase I should be 6 months. MDA will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document. Due to limited funding, MDA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

It is mandatory that the complete proposal submission -- DoD Proposal Cover Sheet, **ENTIRE** Technical Proposal with any appendices, Cost Proposal, and the Company Commercialization Report -- be submitted electronically through the DoD SBIR website at http://www.dodsbir.net/submission. Each of these documents is to be submitted separately through the website. Your complete proposal **must** be submitted via the submissions site on or before the **5:00pm EST, 15 January 2003 deadline.** A hardcopy **will not** be required. If you have any questions or problems with electronic submission, contact the DoD SBIR Help Desk at 1-866-724-7457 (8am to 5pm EST).

PHASE II GUIDELINES

Phase II is the demonstration of the technology that was found feasible in Phase I. MDA selects awardees for Phase II developments through two competitive processes: a routine competition among Phase I awardees that have been invited to submit Phase II proposals; and a Fast Track competition for Phase I awardees that are able to successfully obtain third party cash partnership funds.

The MDA SBIR Program Manager (PM) or one of MDA's executing agents for SBIR contracts will inform Phase I participants of their invitation to submit a Phase II proposal. Fast Track submissions do not require an invitation; see DoD's Fast Track guidelines. Phase II proposals may be submitted for an amount normally not to exceed $750,000. Companies may, however, identify requirements with justification for amounts in excess of $750,000.

Phase II Proposal Submission

If you have been invited to submit a Phase II proposal, please see the MDA SBIR website http://www.winbmdo.com/ for further instructions.

All Phase II proposals must have a complete electronic submission. Complete electronic submission includes the submission of the Cover Sheets, Cost Proposal, Company Commercialization Report, the ENTIRE technical proposal and any appendices via the DoD Submission site. The DoD proposal submission site **http://www.dodsbir.net/submission** will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents are submitted separately through the website. Your proposal must be submitted via the submission site on or before the MDA specified deadline. MDA may also require a hardcopy or your proposal.

MDA FASTTRACK Dates and Requirements:

The Fast Track application must be received by MDA 150 days from the Phase I award start date. Your Phase II Proposal must be submitted within 180 days of the Phase I award start date. Any Fast Track applications or proposals not meeting these dates may be declined. All Fast Track applications and required information must be sent to the MDA SBIR Program Manager at the address listed above, to the designated Contracting Officer's Technical Monitor (the Technical Point of Contact (TPOC)) for the contract, and the appropriate Execution Activity SBIR Program Manager. The information required by MDA, is the same as the information required under the DoD Fast Track described in the front part of this solicitation.

SBIR Phase II Enhancement Policy

To encourage the transition of SBIR research into MDA acquisition programs, MDA has implemented a Phase II Enhancement Policy. Under this policy, MDA will allow extension of an existing Phase II contract for up to one year and will provide additional Phase II funding of up to $250,000, either: 1) as matching funds for non-SBIR MDA funds directed to the Phase II contract; or 2) as transitional funding in anticipation of Phase III, based on a letter of intent to the MDA SBIR PM from a MDA acquisition program that will award a Phase III contract.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria must be met or your proposal will be REJECTED.

____1. Your technical proposal has been uploaded. The DoD Proposal Cover Sheet, the DoD Company Commercialization Report, and the Cost Proposal have been submitted electronically through the DoD submission site by 15 January 2003.

____2. The Phase I proposed cost does not exceed $70,000.

Missile Defense Agency 03.1 Topic List

MDA 03-001	Active Radar System Thermal Management
MDA 03-002	Advanced 3-D Laser Radar
MDA 03-003	Advanced Scene Generation Techniques
MDA 03-004	Early Launch Detection, and Tracking Sensor Concepts
MDA 03-005	Advanced Autonomous Target Acquisition (ATA) and Track Algorithms
MDA 03-006	High Dynamic Range Infrared Scene Projector for Boost Phase Intercept
MDA 03-007	Data Fusion for Missile Defense
MDA 03-008	Decision Theory Research and Development
MDA 03-009	Distributed Battle Management Techniques
MDA 03-010	Image Processing Algorithms for Target Discrimination
MDA 03-011	Integrated Design of Interceptor Guidance, Control, Estimation and Kinetic Warhead System for Ballistic Missile Defense
MDA 03-012	Intercepting Boosting Missile Threats
MDA 03-013	Ladar Components
MDA 03-014	Laser Technology
MDA 03-015	Low Phase Noise Signal Generation
MDA 03-016	Novel Sensor Technology for Booster Typing
MDA 03-017	Low Cost, High Altitude, Unmanned Sensor Platform
MDA 03-018	Air-transportable, Caustic Production System
MDA 03-019	Athermal Infrared Optical Window Material
MDA 03-020	Wavefront Sensing for High Scintillation Environments
MDA 03-021	Lightweight Innovative Composite Tank Concepts
MDA 03-022	Lightweight Mirror Technology
MDA 03-023	Precision High-Force Actuators for Adaptive Optics Mirror Shaping
MDA 03-024	Deformable Mirror (DM) Electronics Miniaturization
MDA 03-025	Advanced Processing of the Optical Surface on Large Lightweight Mirrors
MDA 03-026	Ultra-Lightweight Large-Aperture, SiC Optical Components

MDA 03-027	Beam Control for Extended Range
MDA 03-028	Electron Bombarded Charge Coupled Device (EBCCD)
MDA 03-029	Data Driven Prognostics
MDA 03-030	Multifunctional Structures for Aerospace Applications
MDA 03-031	Advanced Chemical Iodine Lasers
MDA 03-032	Lightweight Low Contamination Materials
MDA 03-033	Ballistic Missile Fuel Tank Ullage Fire/Explosion Modeling
MDA 03-034	Gallium Nitride (GaN) Device Technology Enhancements Leading to Advanced Transmit/Receive (T/R) Modules for Radar Performance Enhancement
MDA 03-035	Technologies Enabling Active Multi-Mode Exo-atmospheric Seeker Based on Range-Resolved Doppler Imaging LADAR and Passive Multi-Color LWIR detection.
MDA 03-036	Technologies Enabling Active Multi-Mode Exo-atmospheric Seeker Based on Angle-Angle Range Imaging LADAR and Passive Multi-Color LWIR detection
MDA 03-037	Advanced In-Flight Interceptor Communications System (IFICS) Error Detection/Correction
MDA 03-038	Advanced Signal/Data Processing Algorithms
MDA 03-039	Multi-color VLWIR Focal Plane Array
MDA 03-040	Thermal Management of GaN Based Power Amplifiers for X-Band Radars (XBR)
MDA 03-041	Reliability, Reproducibility, and Stability of Gallium Nitride (GaN) Based Devices for X-Band Radars (XBR)
MDA 03-042	Data Fusion for Improved Acquisition, Tracking and Discrimination
MDA 03-043	Advanced Real Time Discrimination Architecture
MDA 03-044	Physics Based Discrimination Algorithms
MDA 03-045	Advanced Signal Processing
MDA 03-046	Advanced Engagement Planning
MDA 03-047	Management of Distributed Real-time Databases
MDA 03-048	Define/Demonstrate Beryllium (Be) Substitute Material
MDA 03-049	Innovative Manufacturing Processes
MDA 03-050	Innovative Operating Software
MDA 03-051	Ballistic Missile Innovative Electro-Optic Products
MDA 03-052	Ballistic Missile Innovative Radar and RF Products

MDA 03-053	Ballistic Missile Innovative Signal Processing, Data Fusion and Imaging Products
MDA 03-054	Ballistic Missile System Composite Materials and Structures
MDA 03-055	Ballistic Missile System Innovative Propulsion Products
MDA 03-056	Ballistic Missile System Innovative Radiation Hardened/Tolerant Electronics Products
MDA 03-057	Ballistic Missile System Innovative Batteries
MDA 03-058	Increased Thrust to weight ratio for small Rocket Motors (Directed Attitude Control System)
MDA 03-059	Low Cost IR Windows for High Stress Environments
MDA 03-060	Methodologies For Rapid Software Integration, Test And Transition To An Operational State
MDA 03-061	3-D Modeling of Rocket Motor Plumes
MDA 03-062	On-Orbit Longevity of Cryogenic Cooling Systems
MDA 03-063	Decision Support Tools for Capability-based Systems Engineering
MDA 03-064	Lightweight, High-Precision Inertial Reference Unit
MDA 03-065	Thermal Management System for Solid State Lasers
MDA 03-066	Laser Dynamic Disturbance Mitigation
MDA 03-067	Non-linear Optical Beam Correction
MDA 03-068	Hybrid Vibration Isolation System for Whole-Spacecraft Launch Protection
MDA 03-069	Deployment Mechanisms for Precision Optical Systems
MDA 03-070	On-Orbit Servicing Fluid Couplings
MDA 03-071	Spacecraft Separation System
MDA 03-072	Small Payload Support Module
MDA 03-073	Multiple Purpose Photodiode Array
MDA 03-074	Superlattice Materials for Very Long Wavelength Infrared Detectors
MDA 03-075	Materials for Optical Data Handling
MDA 03-076	Coatings for MercCadTelluride
MDA 03-077	Cloud Background Clutter Suppression for Early Detection and Track
MDA 03-078	Missile Plume Radar Attenuation and Cross Section
MDA 03-079	Missile Plume Temporal Intensity Fluctuation Exploitation
MDA 03-080	Propulsion Related Missile Phenomena

MDA 03-081	Hardware-in-the-loop Test Technologies
MDA 03-082	Soot Formation in Liquid Hydrocarbon and Amine Fuel Combustion
MDA 03-083	Unified Passive and Active Target Signature Simulation
MDA 03-084	Missile Plume Signature Transient Events
MDA 03-085	Laser Attenuation and Backscatter from Missile Plumes
MDA 03-086	Plume Induced Missile Body Heating
MDA 03-087	Advanced Divert and Attitude Control
MDA 03-088	Advanced Seeker Technologies
MDA 03-089	Advanced Avionics
MDA 03-090	Advanced Battery Technology
MDA 03-091	Safe and Arm and Arm and Fire Devices
MDA 03-092	Solid Rocket Motor Propellant Inspection Device
MDA 03-093	Fiber Optic Communication Ribbon
MDA 03-094	Structural Flaw Detection in Composites
MDA 03-095	Development of Advanced Radar Technologies for Missile Defense
MDA 03-096	Operation in Stressing Environments
MDA 03-097	Integrated Data Compression and Security Algorithms
MDA 03-098	Robust Discrimination of Ballistic Targets
MDA 03-099	Electronic Hardening
MDA 03-100	Lightweight Energy Production and Storage
MDA 03-101	Propulsion and Propeller Technology for High Altitude Airships (HAA)
MDA 03-102	Long-Endurance, Autonomous Vehicle Control

MISSILE DEFENSE AGENCY 03.1 TOPIC DESCRIPTIONS

MDA 03-001 TITLE: Active Radar System Thermal Management

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: MDA/AC

OBJECTIVE: The MDA has the need for various radar antenna radar system thermal management and cooling technologies for BMD applications. Therefore, a significant investment is made each year in the continued development of increasingly robust and sophisticated cooling system technologies, which may eventually find their utilization in a ballistic missile technology or major defense acquisition programs. Furthermore, advanced radar thermal management systems, components, sub-components, and piece part specifics are constantly under evaluation by the various BMD elements for replacement by the latest technology developments from industry. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

DESCRIPTION: Higher power levels of future MDA advanced radar antenna systems require state-of-the-art capabilities for waste thermal energy acquisition, storage, transport, and dissipation. Technology advancements are required in thermal management for power generation systems, T/R modules, and all associated electronics. Of specific interest are concepts to transfer heat from high power T/R modules to a heat dissipation system. Concepts, devices, and advanced technologies for all types of power cycles are sought, which can satisfy projected advanced radar system requirements.

PHASE I: Demonstrate the feasibility that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future MDA systems consideration.

PHASE II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

PHASE III: Develop pre-production and production components and sub-systems for integration into MDA advanced radar systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: These technologies could be applied in many RF applications such as the telecommunications industry, commercial airport radar systems, and automotive industry.

REFERENCES:
1. R. Kirschman (ed.), “High-temperature electronics”, IEEE Press (New York, 1999).
2. P.L. Dreike et al., “An overview of high-temperature electronic device technologies and potential applications”, IEEE Trans. on Components, Packaging and Manufacturing Technol., pp. 594-604 (1994).
3. Weimer, “Thermochemistry and Kinetics”, Carbide, Nitride and Boride Materials Synthesis and Processing, edited by A. Weimer, Chapman and Hall, New York, 79-113, (1997)
4. Ortega, A., Agonafer, D, and Webb, B. W., Eds, “Heat Transfer in Electronic Equipment,” ASME HTD, Vol. 171, 1991.
5. Kreith, F. and Black, W. Z., 1980, Basic Heat Transfer, Harper & Row, New York.
6. G.F. Jones, “Analysis of a Gas-to-Plate Heat Exchanger for Cryogenic Applications,” ASME HTD, Vol. 167, 1991.
7. G.F. Jones, "Temperature and Heat-Flux Distributions in a Strip-Heated Composite Slab," J. Heat Transfer, Vol. 108, 1986, p. 226-229.
8. J.P. Holman, Heat Transfer, Fifth Edition 1981, McGraw-Hill Book Company.
9. Mallik, A.K.; Peterson, G.P.; Weichold, M.H. “On the Use of Micro Heat Pipes as an Intregal Part of Semiconductor Devices”, Proceedings of the 3 rd Joint Conference of ASME-JSME Thermal Angering, 1991 Pg 393-401.
10. A.V. Virkar, T. B. Jackson and R. A. Cutler, "Thermodynamic and Kinetic Effects of Oxygen Removal on the Thermal Conductivity of Aluminum Nitride," J. Am. Ceram. Soc., 72[11] 2031-2042 (1989).

11. W.C. Nieberding, J.A. Powell, “High-temperature electronic requirements in aeropropulsion systems”, IEEE Trans. Industrial Electronics, pp. 103-106 (1982).

KEYWORDS: radar, T/R module, HPA, Wide Band gap, thermal management, power, RF, antenna array

MDA 03-002 TITLE: Advanced 3-D Laser Radar

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: MDA/AC

Objective: Develop advanced, compact 3-D laser radar to enhance missile defense kill vehicle discrimination capabilities.

Description: Active 3-D sensing provides an estimate of range and hence time-to-go, needed for hit-to-kill guidance against an accelerating target as well as providing 3-D booster hardbody shape, enabling precise aimpoint selection. The ladar can be configured to measure active polarization signatures as well as range. Active polarization techniques have been proven to penetrate scattering media, such as plumes, better than unpolarized active approaches.

Phase I: Develop techniques and perform analysis to demonstrate the ability to develop 3-D laser radar.

Phase II: Develop a prototype implementation of components. Develop a test plan, test the prototypes, compare with predictions and explain significant variations from the predicted performance. In addition, describe techniques for fusing the 3-D laser radar data with passive optical (visible and/or infrared) data.

Phase III: Test and demonstrate the compact laser radar system for transition to missile defense elements.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The techniques developed could be applied to commercial sensor systems.

References: None

KEYWORDS: Laser radar, ladar, discrimination, sensors

MDA 03-003 TITLE: Advanced Scene Generation Techniques

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: MDA/AC

OBJECTIVE: Develop advanced scene generation techniques, including countermeasure modeling, in a variety of wavebands (IR, MMW, visible and ultraviolet, for both active (e.g., LADAR) and passive sensors) to support boost phase algorithm development and testing for target acquisition, tracking, discrimination, decision making, and intercept.

DESCRIPTION: The Missile Defense Agency (MDA) is interested in advancing the current state of the art for scene generation techniques, including countermeasure modeling, to support boost phase algorithm development. It is important to model all aspects of the target in boost phase including staging, shroud ejection, and General Energy Management (GEM) maneuvers. The scenes generated need to span all relevant engagement space and include time dependent spatial, temporal, and spectral sampling regimes. To test the algorithms the scene generation models need to provide time dependent high-fidelity simulations that can be utilized from target acquisition to intercept. The models need to allow for arbitrary vehicle operational state, position, orientation, and atmospheric condition. The computations need to be performed as a function of time to allow complex vehicle dynamics to be simulated.

Phase I: Demonstrate the feasibility that a new and innovative research and development approach can meet any of the broad needs discussed in this topic to support scene generation needs for future MDA boost phase algorithm development.

Phase II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept for the approach described, and demonstrate a degree of commercial viability or application directly to MDA.

Phase III: Fully integrate the developed software to allow testing of existing and potential boost phase algorithms.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This work could be applied to commercial Visible, UV, IR, and Ladar scene generation software.

REFERENCES: Synthetic Scene Generation Model Papers, Validation Reports & Presentations http://vader.nrl.navy.mil/ssgm/info/refs.html.

KEYWORDS: Scene Generation, Countermeasures, Infrared, Visible UV, Ladar

MDA 03-004 TITLE: Early Launch Detection, and Tracking Sensor Concepts

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: MDA/AC

OBJECTIVE: Develop and demonstrate high payoff all-weather surveillance and fire control technologies for transition to Boost Defense Segment systems.

DESCRIPTION: An advantage of a boost phase intercept system is that the target is moving slower, its bright plume offers easier tracking and the boosting missile is more vulnerable. However, the launch locations can be deep in the adversary's territory, requiring substantial standoff ranges. Detecting the launch as early as possible is essential to developing a track, determining the nature of the launch, and initiating weapons release. Because the launch might occur under a cloud cover, new and innovative approaches to early launch detection and tracking (ELDT) are needed. Sensor characteristics include: large standoff range, wide area surveillance, all weather (high availability), prompt detection time, high probability of detection and low probability of false alarm, and initial track accuracy. This SBIR addresses the definition, concept development, and demonstration of ELDT sensors. It is not primarily a phenomenology effort.

PHASE I: Phase I SBIR efforts should concentrate on the development of the fundamental concepts. This could include demonstration of a process or fundamental principle in a format that illustrates how the technology can be further developed and utilized in an ELDT sensor. This effort should include plans to further develop and exploit the concept in Phase II.

PHASE II: Phase II SBIR efforts should take the concept of Phase I and design/develop/demonstrate a breadboard sensor to demonstrate the concept. The sensor may not be optimized to flight levels but should demonstrate the potential of the working prototype sensor to meet emerging operational requirements. Demonstration of the potential improvements in mass, input power, and performance parameters should be included in the effort.

PHASE III: Potential opportunities for transition of this technology include the commercial sector and military programs that would benefit from improved all weather missile launch detection and tracking

PRIVATE SECTOR COMMERCIAL POTENTIAL: Opportunities for developing commercial applications of the technology include remote/environmental sensing, rocket launch detection and characterization by NASA and environmental monitoring agencies.

REFERENCES:

1. Kristl, J., Clark, F., “Application of Temporal Plume Intensity Modulation to Boost Phase Intercept”, Military Sensing Symposium, Missile Defense Sensors, Environments and Algorithms, pp. XXX
2. Battleson, K., Park, S., Lafrance, P., Fraser, J., Argo, P., Halbgewachs, R., Weber, T., Kiessling, J., “Parameters Affecting Boost Phase Intercept System: Early Launch Detection and Track”, ”, Military Sensing Symposium, Missile Defense Sensors, Environments and Algorithms, pp. XXX
3. Smith, D. A., Holden, D., Heavner, M. J., “Passive RF Sensing for Missile Defense”, ”, Military Sensing Symposium, Missile Defense Sensors, Environments and Algorithms, pp. XXX

KEYWORDS: launch detection, surveillance, tracking, all weather, boost phase

MDA 03-005 TITLE: Advanced Autonomous Target Acquisition (ATA) and Track Algorithms

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: MDA/AC

OBJECTIVE: Develop advanced ATA algorithms applicable for Visible, UV, IR, and Ladar sensor systems viewing the boost phase of a missile flight.

DESCRIPTION: This SBIR topic seeks advancement of the current state of the art for ATA algorithms that typically perform detection, classification, and identification of targets detected by Visible, UV, IR, and Ladar sensor systems. The focus of this SBIR shall be on the boost phase of a missile flight. The complexity of the imagery collected for a booster viewed from launch to burnout includes hardbody, plume, and backgrounds for varying viewing conditions and geometries. ATA algorithms of interest are sought for sensor systems viewing the boost phase of a missile flight from endoatmospheric and exoatmospheric platforms/interceptors.

PHASE I: Develop a design for advanced ATA algorithm suite. Demonstrate the feasibility of the ATA algorithms by implementing a prototype thread (such as a MATLAB version of the algorithm) and evaluating it with synthetically generated threat data of a booster from viewed from launch to burnout.

PHASE II: Fully develop the ATA algorithm suite in both software and hardware. The hardware design should be capable of running in real-time. Demonstrate the advanced ATA algorithm suite performance by the driving the software and hardware with synthetic/real image sequences.

PHASE III: Fully integrate the developed software/hardware advanced ATA algorithm suite into relevant missile defense systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The ATR algorithms could be applied to commercial Visible, UV, IR, and Ladar sensor systems.

References: None

KEYWORDS: sensor systems, Visible, UV, IR, Ladar, autonomous target acquisition, ATA

MDA 03-006 TITLE: High Dynamic Range Infrared Scene Projector for Boost Phase Intercept

TECHNOLOGY AREAS: Sensors, Space Platforms

ACQUISITION PROGRAM: MDA/AC

OBJECTIVE: Develop an infrared scene projection capability for very high contrast target images.

DESCRIPTION: The goal of this topic is to pursue the development of infrared scene projection technology beyond the current state-of-the-art. Current projection technology based on resistive arrays has many benefits including flickerless emission, broadband output, greater than 512^2 spatial resolution, and high framerates. However, the dynamic range of this technology does not provide for radiometric duplication of the full range of target scenarios likely to be encountered by future MDA weapons systems. Targets with hot engine exhausts or rocket plumes, and infrared countermeasures, are examples of the target set that will stress the test community's ability for radiometric duplication. Innovative approaches are required for simulation of spatially extended objects whose apparent temperature may exceed 2000K. For the purpose of defining approaches, the projector should be realizable for testing of a specific sensor having a two-micron bandpass anywhere within the 2-12 micron band. Ideally, the projection concept should be able to achieve at least a 512^2 spatial resolution, provide a non-modulated output, and, if pixelated, achieve pixel response times of less than 1.25 msec.

PHASE I: Infrared projector concept definition and proof of principle demonstration.

PHASE II: Infrared projector detailed design and prototype development and demonstration.

PHASE III: Design refinement and product transition to MDA HWIL test facilities.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The entire hardware in the loop test community would benefit directly from this development. All weapon programs relying on infrared sensors against high contrast targets would benefit. Commercial products designed for fire fighting or search and rescue could use this product for developmental testing or training.

REFERENCES:
R.A.Thompson, et al., "HWIL Testbed for Dual-Band Infrared Boost Phase Intercept Sensors," Proceeding from 2002 Meeting of the MSS Specialty Group on Missile Defense Sensors, Environments, and Algorithms, 5-7 February 2002.
B.E.Cole, et al., "High-Speed large-Area pixels Compatible with 200-Hz Frame rates," Proceedings of SPIE, Vol 4366, Pgs. 121-129, April 2001

KEYWORDS: IR, infrared, projector, hardware-in-the-loop, HWIL, display, resistor array, test, boost phase intercept, plume

MDA 03-007 TITLE: Data Fusion for Missile Defense

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: MDA/AC

OBJECTIVE: Develop data fusion algorithms that utilize ground, high-altitude, or satellite sensor data together with onboard missile/kill-vehicle sensors to provide an enhanced target discrimination capability.

DESCRIPTION: Target discrimination (the ability to identify or engage any one target when multiple targets are present) during National Missile Defense (NMD) midcourse engagement is a complex technological hurdle. Missile guidance sensors need to discriminate among targets, decoys, and penetration aids in an extremely short detect-to-kill time. Feature differences among decoys, penetration aids, and targets are not adequate for discrimination by current passive IR missile sensors. A potential solution to the problem may be in the use of sensor assets that are traditionally used for midcourse trajectory correction to provide discrimination maps that can then be fused with other sensor information during the kill phase of the missile sequence, for example end-to-end state vector tracking. Such a solution must be able to operate in a low bandwidth environment and to support low latency algorithms.

PHASE I: It is anticipated that this phase will define and develop potential data fusion concepts that aid in the target discrimination problem.

PHASE II: Develop and test a prototype image processing software package using real or simulated data. Validate the concept described in Phase I in a laboratory environment.

PHASE III: The innovative algorithms and image processing techniques developed under this effort will find Phase III applications in military systems requiring autonomous stand-off detection of objects in the presence of sensor clutter induced by scene structure and the data-collection process and by spectral interferences. The algorithms will potentially be useful in non-military applications requiring autonomous detection of objects of interest under similar conditions of scene-induced and sensor-induced clutter, noise, and spectral interferences. Potential commercial applications include processing systems for object detection, and characterization and tracking in fields such as medicine, industrial processing, and quality control.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This target discrimination system could be applied to high resolution tracking of commercial air or ground vehicles.

KEYWORDS: Data Fusion, Radar, Infrared, Target Discrimination, Multiple Sensor Fusion Algorithms.

MDA 03-008 TITLE: Decision Theory Research and Development

TECHNOLOGY AREAS: Battlespace

ACQUISITION PROGRAM: MDA/AC

OBJECTIVE: Develop Decision-Theoretic enabling technologies to support the next-generation MDA BMC2 architecture.

DESCRIPTION: It's anticipated that the Decision Architecture will utilize networks to codify hypotheses and associated likelihoods. Therefore, areas of interest include Dynamic Networks, Optimization utilizing data represented in decision graphs, approximate solutions, network pruning, and hybrid (discrete and continuous data) networks. These areas are intended to suggest topics but are not meant to be restrictive.

PHASE I: Develop methodologies and show feasibility (and computability) by analytic or other means. Define limits of applicability for both theoretical and computational reasons.

PHASE II: Develop a prototype implementation of algorithms utilizing the candidate techniques. Consider computational performance as well as efficacy. Test and evaluate the technique(s) using progressively more complex cases, including boundary cases, stressing cases and cases beyond the anticipated limits. Characterize computational and efficacy degradation near and beyond algorithm boundaries.

PHASE III: This SBIR would have direct applicability to future MDA BMC2 programs. Also, the techniques developed would have applicability for decisionmaking systems that work with uncertainty in other areas (e.g., medical diagnostics).

REFERENCES: None

KEYWORDS: Bayesian Nets, Dynamic Nets, Optimization, Game Theory, Pruning, Likelihood, Objective Function

MDA 03-009 TITLE: Distributed Battle Management Techniques

TECHNOLOGY AREAS: Battlespace

ACQUISITION PROGRAM: MDA/AC

Objective: Develop the necessary infrastructure to support Distributed next-generation BMC2.

Description: The next-generation BMC2 architecture will be distributed in execution while being homogeneous in data and algorithms, to the extent consistent with overall system robustness. Consequently, areas of interest include distributed processing, management and synchronization of distributed duplicate data, and wide bandwidth comm. approaches needed to support the BMC2.

Phase I: Develop methodologies, estimate the resulting performance and performance limits and show feasibility by simulation, analysis or other means. Design and build software tools supporting parametric analyses of these methods and use these tools to analyze the infrastructure requirements.

Phase II: Develop a prototype implementation of algorithms utilizing the candidate methodologies. Develop a test plan and obtain/design a minimal framework which is adequate for executing the test program for these algorithms. Identify the most likely failures due to overload, system shortcomings or hostile activities. Consider computational performance as well as efficacy. Test and evaluate the algorithms using progressively more complex cases, including stressing cases and cases beyond the predicted boundaries. Characterize computational and efficacy degradation near and beyond the algorithm boundaries.

Phase III: This SBIR would have direct applicability to future MDA BMC2 programs.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The techniques developed would have applicability for decisionmaking systems that work with uncertainty in other areas (e.g., medical diagnostics).

References: None

KEYWORDS: Distributed Processing, Distributed Database Synchronization, Wide Bandwidth Communication

MDA 03-010 TITLE: <u>Image Processing Algorithms for Target Discrimination</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: MDA/AC

OBJECTIVE: Design image processing algorithms that aid in the missile defense discrimination process.

DESCRIPTION: Target discrimination (the ability to identify or engage any one target when multiple targets are present) during National Missile Defense (NMD) engagement is a complex technological hurdle. Missile guidance sensors need to discriminate among targets, decoys, and penetration aids in an extremely short detect-to-kill time. Feature differences among decoys, penetration aids, and targets are not adequate for discrimination by current missile passive IR sensors. A potential piece of the solution to the problem may be in the use of novel image processing algorithms that perform the target discrimination task. The algorithms proposed can perform some of the following functions: image contrast enhancement, image detail sharpening, and spatial-temporal processing. The algorithms developed should be computationally fast and can work on image data produced by a variety of sensors, e.g. optical, IR, LIDAR, etc.

PHASE I: It is anticipated that this phase will define and develop candidate image processing concepts that aid in the target discrimination problem.

PHASE II: Develop and test a prototype image processing software package using real or simulated data. Validate the concept described in Phase I in a laboratory environment.

PHASE III: Automated transfer of imagery or equivalent information from one active sensor to another with different performance parameters could potentially be used to cue sensors to track objects, useful in tracking object's progress in processes and providing a means of process control.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The techniques developed here will have application to commercial image processing systems that would benefit from contrast enhancement and detail sharpening.

KEYWORDS: Algorithms, Image Processing, Data Fusion, Radar, Infra-red, Target Discrimination.

MDA 03-011 TITLE: Integrated Design of Interceptor Guidance, Control, Estimation and Kinetic Warhead System for Ballistic Missile Defense

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: MDA/AC

OBJECTIVE: Develop integrated methods for missile guidance, control and estimation system design for ballistic missile defense interceptors with hit-to-kill capability. Demonstrate, via simulation, an improved level of performance for the integrated design against ballistic missile targets.

DESCRIPTION: Integrated design methodologies are desired to improve the accuracy of anti-ballistic missile weapon systems, and also to decrease the time it takes to go from weapon concept to prototype. Previous research has demonstrated that an integrated design methodology for the guidance, control and estimation systems can yield significant improvements in interceptor performance. The objective of this SBIR is to demonstrate the integrated synthesis of guidance, estimation and control systems for a specified missile concept. Proposed design methodologies must start from a given configuration description and set of specifications for vehicle, sensors and actuators, and must demonstrate the complete synthesis of the various components of the integrated system.

Examination of multiple guidance and control integrated design techniques is desired that effectively deal with the ballistic missile target. Incorporation of newly emerged nonlinear guidance and control methods such as the State Dependent Riccati Equation method, Feedback Linearization, Finite Horizon Linear Quadratic design and other techniques should also be considered for the integrated design. Investigations should also include examination of new guidance laws which compensate for target maneuvers and fire control errors.

The effectiveness of the integrated design should be demonstrated with a sufficiently realistic nonlinear system model of the candidate interceptor missile. A primary figure of merit should be interceptor hit-to-kill performance against the ballistic missile target, and the benefits of the integrated synthesis must be convincingly demonstrated.

PHASE I: Demonstrate a preliminary integrated guidance-control-estimation system design using representative missile and target models. Demonstrate by simulation that hit-to-kill performance is achievable against maneuvering ballistic missiles.

PHASE II: Evaluate alternative integrated guidance-control-estimation design architectures. Assess the performance of each and down select a chosen design. Fully exercise the selected integrated design for the selected missile over the complete engagement envelope.

PHASE III: Transition research to missile system designer(s). Participate with development contractor(s) in performing hardware-in-the-loop testing of an integrated design, and in verifying performance of the design via demonstration flight testing.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Besides the obvious military aerospace role, integrated design methods have direct applications in the areas of civilian aviation, autonomous vehicles, maritime systems, ground transportation, environmental protection, security monitoring and others. Algorithms and methods developed under this SBIR will be useful in a wide range of military and commercial systems.

KEYWORDS: Integrated guidance and control, ballistic missile defense, hit-to-kill, missiles, guidance laws

MDA 03-012 TITLE: Intercepting Boosting Missile Threats

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: MDA/AC

OBJECTIVE: Improve interceptor missile performance against boosting missile threats by improving the guidance law.

DESCRIPTION: To achieve a kill, the interceptor must predict unknown threat motion. Using the best prediction, the interceptor flies towards a collision. However, prediction errors will cause a miss. The interceptor predicts again and corrects its flight path. Prediction / correction continues to the end. The intercept depends on threat maneuver, interceptor guidance law, interceptor maneuverability, and encounter conditions. The reference shows how to generate the optimal evasion maneuver for any scenario. With a coordinated search, it is possible to find the guidance law scoring best against even the corresponding optimal maneuver. If this optimal maneuver results in a miss distance that is within the kill radius of the interceptor, the interception law will kill the threat regardless of its maneuver.

PHASE I: Assess improved performance opportunities against ballistic missile threats. Estimate threat maneuver characteristics which must be countered. Choose candidate closed-form guidance laws for improvement as well as guidance laws requiring search techniques.

PHASE II: As a check case, implement the reference PN guidance law and derive the optimal evasion against it. Extend this guidance law into 3D space and derive the optimal evasion against it. Choose the best two of the above closed-form guidance laws and derive the optimal evasions against them. Determine the most desirable guidance law.

PHASE III: As a second check case, implement the reference MMT search-based guidance law and derive the optimal evasion against it. Extend this guidance law into 3D space and derive the optimal evasion against it. Choose the best three of the above search-based guidance laws and derive the optimal evasions against them. From these three determine the most desirable guidance law.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This methodology can be reversed to improve the survivability of civilian aircraft, such as commercial airliners maneuvering to avoid in-air collisions.

Reference: William S. Beebee, “Optimal Hypersonic Pursuit Evasion”, (Sc.D. Thesis), Cambridge: Massachusetts Institute of Technology, Department of Aeronautics and Astronautics, 1975.

KEYWORDS: Interceptor guidance, cruise and ballistic missile interception, atmospheric reentry. maneuvering ballistic missiles

MDA 03-013 TITLE: <u>Ladar Components</u>

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: MDA/AC

Objective: Develop ladar components to support active and Bi-static sensing

Description: MDA is interested in ladar components. Particular areas of interest include detectors (angle-angle, range, and Doppler), advanced adaptive optics, relay mirror technologies, processors, and algorithms

Phase I: Develop methodologies, establish feasibility by analysis or other means and estimate the resulting performance improvements over current capabilities and the performance limits. Address supporting technologies needed such as power and cooling. Also address whether the improved performance can only be realized if other technologies are improved in concert, name these technologies, and define the improvements needed.

Phase II: Develop a prototype implementation of components. Develop a test plan, test the prototypes, compare with predictions and explain significant variations from the predicted performance. Identify the most likely failure modes due to overload, system shortcomings or hostile activities. Test and evaluate the components using progressively more complex cases, including stressing cases and cases beyond the predicted boundaries. Characterize computational and efficacy degradation near and beyond the performance boundaries.

Phase III: This SBIR would have direct applicability to future MDA laser programs. Also, the techniques developed would have applicability for systems in other areas (e.g.,weapons).

PRIVATE SECTOR COMMERCIAL POTENTIAL: The techniques developed could be applied to commercial sensor systems.

References: None

KEYWORDS: Detectors (angle-angle, range, and Doppler), Advanced Adaptive Optics and Beam Cleanup, Relay Mirror Technologies, Processors, Algorithms, Amplification

MDA 03-014 TITLE: Laser Technology

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: MDA/AC

Objective: High-Power Laser Technology

Description: Develop technology supporting high-power laser ladar and illuminator usage in MDA. Technologies of interest include high-power chemical lasers (e.g., medium to high energy Hydrogen Fluoride technology), high power solid-state lasers, and high power density solid-state lasers exhibiting high power, high efficiency, and high beam quality. Weapon guidance laser concepts employing UV/Nd:Yag are also of interest.

Phase I: Develop new technology, show feasibility and (roughly) estimate the resulting performance improvement over current systems and performance limits. Consider computational/physical performance as well as efficacy. Estimate size and weight and needs for support (power, cooling, beam cleanup and focusing). Address whether other technologies must be improved in concert in order to achieve the estimated performance gains. Address expected difficulties in manufacturing and maintenance.

Phase II: Develop a test plan and perform more elaborate analyses and/or tests designed to identify performance characteristics and boundaries, identify problems and limitations, and characterize computational/physical and efficacy degradation before, at, and beyond the boundaries. Where feasible, develop and test breadboards/brassboards. Identify the most likely failure modes due to overload, system shortcomings or hostile activities.

Phase III: This SBIR would have direct applicability to future MDA laser programs. Also, the techniques developed would have applicability for weapon systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technology developed could be applied to commercial high energy laser systems.

References: None

KEYWORDS: Chemical Lasers, Solid State Lasers, Hydrogen Fluoride Lasers, High Power, High Efficiency, Beam Quality, High Power Density, UV, Nd:Yag, Beam Focusing, Cooling

MDA 03-015 TITLE: Low Phase Noise Signal Generation

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: MDA/AC

OBJECTIVE: Radar operational requirements include ever-increasing demands for lower-phase noise signal and waveform generation. The MDA is looking for feasibility demonstrations of innovative ideas on how to extend the performance limits of what is achievable with the present state of the art for oscillators, frequency synthesizers and waveform generators. Proposals may include the use of distributed techniques, which would effectively place multiple parallel copies of a digitally-controlled component of the radar exciter to take advantage of noise de-correlation and produce a lower total phase noise than with a single component. Research and development efforts selected under this topic shall demonstrate the technical feasibility of how to achieve increased phase noise performance and should address issues of cost and size, especially in the case of distributed approaches. Proposed efforts will be considered which address the improvement of a specific exciter component as well as those that address the architecture issues associated with paralleling state of the art components.

DESCRIPTION:
Phase I: Identify potential innovative research and development approaches to address the exciter performance issues discussed in this topic.

Phase II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

Phase III: Develop pre-production and production components and sub-systems for integration into MDA advanced radar systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: It is expected that many of these technologies will have applications in the telecommunications, space and meteorology sectors.

REFERENCES:
1. R. S. Raven, “Requirements for Master Oscillators for Coherent Radar,” Proc. IEEE, Vol. 54(2), pp 237-243, Feb. 1966.
2. M. J. Underhill, “Fundamentals of oscillator performance,” Elec. & Comm. Eng. J., pp185-193, Aug 1992.
3. M. M. Driscoll, A. C. Hazzard, and D. G. Opdycke, “Design and Performance of an Ultra-Low Phase Noise Radar Exciter,” 1994 IEEE Int. Freq. Control Symp. Digest, pp 647-650.
4. S. J. Goldman, “Phase Noise Analysis in Radar Systems,” John Wiley & Sons, 1989.
5. V. S. Reinhardt, “Frequency and Time Synthesis – A Tutorial,” http://www.ieee-uffc.org/freqcontrol/tutorials/FCS%20Tutorials%2000/2000TutorialProgram.htm
6. B. Cantrell, J. de Graaf, F. Willwerth, G. Meurer, L. Leibowitz, C. Parris, and R. Stapleton, “Development of a Digital Array Radar (DAR), IEEE AESS Systems Magazine, pp. 22-27, Mar. 2002.

KEYWORDS: radar; exciters; oscillators; synthesizers; waveform generators; direct digital synthesis; phase noise; AM noise; PM noise; side-band noise.

MDA 03-016 TITLE: Novel Sensor Technology for Booster Typing

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: MDA/AC

Objective: Develop sensor technology that facilitates precise typing of threat boosters as early as possible in the flight timeline.

Description: With the increased emphasis on engaging threat missiles early in the flight timeline, early determination of the threat characteristics, such as booster type, is critical. This SBIR topic seeks innovative approaches to sensor technology to provide early detection of vehicle launch and early identification of threat booster type.

Phase I: Design and conduct experiments to provide proof of principle for improved performance of the sensor technology in the booster typing role.

Phase II: Develop a prototype of the proposed sensor technology, capable of preliminary test and evaluation from an airborne test platform.

Phase III: This SBIR would have direct applicability to ongoing launch detection and tracking programs for missile defense systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This work could be applied to the advancement of commercial optical sensors.

References: None

KEYWORDS: booster typing, algorithms, optical sensors

MDA 03-017 TITLE: Low Cost, High Altitude, Unmanned Sensor Platform

TECHNOLOGY AREAS: Air Platform, Sensors

ACQUISITION PROGRAM: MDA/AC

Objective: Develop a low cost unmanned air vehicle capable of carrying observation platforms to high altitude for observation of missile launches and flights.

Description: With the increased reliance of weapons programs on simulation to support test and evaluation, observation of missile test flights is critical to providing validation of those simulations. This is particularly important in the boost phase of missile flight, where high-resolution data taken at high altitude is very useful. At the same time, commercial off-the-shelf balloon technology has enabled university and amateur organizations to easily exceed 100,00 feet altitude.1,2 This SBIR topic seeks innovative solutions to the problem of lifting a light-weight observation platform to high altitudes using off-the-shelf balloon or airship components.

Phase I: Conduct design experiments to define the trade space of platform design / cost, observation altitude, payload mass and cost. Provide a preliminary design that optimizes these design factors.

Phase II: Develop a prototype platform based on the preliminary design. Testing during this phase will emphasize demonstration of lifting capability and vehicle controllability.

Phase III: This SBIR would have direct applicability to on-going and future test programs for missile defense systems. In addition, increased vehicle endurance and application of low-observable technologies may allow this platform to function in other intelligence and battlefield support roles. In addition to surveillance applications, there are weather balloon applications.

Technologies in this area will have direct applicability to flexible, low cost airborne communications solutions being developed for commercial applications. As a communications technology, it is anticipated that commercial and industrial transferability and applicability will be high.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technology could be applied to commercial applications, such as cell phone tower replacement.

REFERENCES:
1. University of North Dakota High Altitude Balloon Project, http://balloons.aero.und.edu/habp.
2. MSAM: Top Hat Program: http://topweb.gsfc.nasa.gov/index.html

KEYWORDS: Low cost, High altitude, Optical, Boost-Phase, Balloon, Airship

MDA 03-018 TITLE: Air-transportable, Caustic Production System

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: MDA/AL

OBJECTIVE: Develop and demonstrate a compact, air-transportable, rapidly assembled, liquid caustic production system (pilot-scale).

DESCRIPTION: The system must produce a minimum of 1,000 kg per hour of caustic solution as a mixture of potassium hydroxide (KOH), sodium hydroxide (NaOH), and lithium hydroxide (LiOH). The system must produce adequate de-ionized water from potable water supplied at the operating site. The system must utilize anhydrous KOH and NaOH and utilize LiOH monohydrate (LiOH.H20) as starting reagents. The system must provide for all possible orders of addition for each of the solid caustics in the blend procedure. The system must handle solid caustic from commercially supplied standard containers; i.e., drums or super-sacks. The system must have adequate controls and automation to allow the selection of specific proportions of each caustic and water as well as provide for the selection of a pre-determined blend procedure. The system must has sufficient storage for 6,000 kg of caustic solution. The system must have adequate automation and controls to produce specified formulations to within ±0.5%.

Phase I: (1) Develop a process flow diagram with material and energy balance for a deployable (military air transportable) caustic production facility capable of producing 1,000 kg/hour. (2) Develop piping and instrumentation diagrams (P&ID's) for a deployable, air-transportable caustic production facility. (3) Prepare a major equipment list and specifications to include materials of construction and power requirements. (4) Develop a preliminary layout design with a general arrangement of equipment. And (5) prepare an electrical single line diagram for the system.

Phase II: (1) Complete detailed engineering of caustic production system and prepare level-3 "build-to" drawings. (2) Procure and fabricate caustic production system. (3) Demonstrate production system setup, checkout, operation, and breakdown at Tyndall AFB, FL.

Phase III: If Phase II is successful, the system will be scaled up to full-scale (approximately 3x to 5x) and 3 to 10 systems will be produced for weapon system testing, operational training, and weapon system deployment/employment.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The chemical processing industry would be able to utilize this technology for intermittent and remote location situations where high-strength caustic solutions are needed (oil-field, superfund sites, waste disposal locations, etc.) without the inherent hazards of transporting liquid caustic. In addition, this technology may have military applications for chemical and biological decontamination.

References: (1) High-strength, multi-component caustic formulations (contact Hurley) (2) Rapid caustic blending procedures (contact Hurley)

KEYWORDS: caustic; liquid-caustic production; caustic heat of solution; caustic solid precipitation; multi-component phase diagrams; caustic blending.

MDA 03-019 TITLE: Athermal Infrared Optical Window Material

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: MDA/AL

OBJECTIVE: Develop bulkhead window material with minimal optical thermal distortions.

DESCRIPTION: Develop innovative materials or improve existing materials that reduce the optical aberrations caused by temperature variations within the material. The objective is a material with slightly negative change of index of refraction as a function of temperature balanced with the lensing effects of the thermal expansion of the window. High power laser systems often require optical windows mounted in pressure bulkheads. These windows must be capable of surviving high power laser fluences, while minimizing aberrations that typically result from window heating at local laser hot spots. The window must have very low absorption and scatter characteristics at the laser wavelengths. Additionally, it must be capable of accepting a high polish and anti-reflective surface coatings. The material(s) used must be affordable and available in sufficient volumes.

PHASE I: Define the proposed material concept, specific material requirements, and predict the performance of the optical bulkhead proposed design. Demonstrate basic material concepts in a laboratory environment.

PHASE II: Provide a prototype optical component and laboratory demonstration to mutually agreed performance parameters. Demonstration optical bulkhead with capable to support ground demonstration in a government facility and be qualifiable for an airborne experiment. The prime consideration must be deliverable optical hardware and a clear demonstration of the high-performance optical material that will demonstrate a 20-year lifetime.

PHASE III: Airborne Laser, Space Based Laser, Ground Based Laser, and Navy HEL programs will benefit from new material that can reduce aberrations.

PRIVATE SECTOR COMMERCIAL POTENETIAL: Commercially all optical systems are subject to the negative affects of thermally induced aberrations. Development of materials that eliminate or reduce aberrations will have signification application commercially (example laser cutting/welding applications).

REFERENCES: (1) D.C. Tran et al, “Heavy Metal Fluoride Glasses and Fibers: A Review”, IEEE J Lightwave Tech, LT-2, 566 (1984). (2) D.C Tran et al, “Preparation and Properties of High Optical Quality IR Transmitting Glasses and Fibers Based on Metal Fluorides”, SPIE, Vol 618 (1986). (3) D.C. Tran et al, “Light Scattering in Heavy Metal Fluroide Glasses in Infrared Spectral Regions”, Electronics Letters, 22, 117 (1986)

KEYWORDS: Infrared windows; thermal aberrations; high power laser systems; oxyfluoride glass; laser windows; low absorption & scatter

MDA 03-020 TITLE: Wavefront Sensing for High Scintillation Environments

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: MDA/AL

OBJECTIVE: Demonstrate innovative wavefront sensing methods that lead to efficient wavefront reconstruction of an optical wavefront in the presence of high scintillation and the resulting branch points in the phase.

DESCRIPTION: The Air Force is interested in the propagation of laser beams over long atmospheric paths. Two systems of interest are the Airborne Laser (ABL) and Relay Mirror. These systems require operation in high scintillation environments where branch points occur in the phase of the propagated beam. Typically, a probe beam gathers information about the atmospheric phase, and an approximate conjugate phase is applied to the outgoing beam. ABL will use active illumination of a missile body for the adaptive optics beacon whereas the relay mirror will use a well placed point source on the relay mirror itself. We say that ABL will have an extended beacon and the relay mirror will have a point source beacon. In either case, current practice derives the approximate phase from the phase gradient as sensed by a Hartman-style wavefront sensor. Intensity scintillation and the associated branch points hamper the reconstruction of the phase from the wavefront sensor measurement. Intensity scintillation yields low signal-to-noise ratios on some subapertures. Branch points complicate the phase reconstruction process and lead to difficulty in placing the optimal phase on a continuous face sheet mirror. There are indications that other forms of wavefront sensing might perform better in the high scintillation environment. For example, shearing interferometer sensing and/or exponential reconstructors may provide an advantage-and there may be concepts. This effort seeks innovative wavefront sensing methods that lead to efficient wavefront reconstruction of an optical wavefront in the presence of high scintillation and branch points. The concept must support high bandwidth operation – 2000 Hz or more – at resolutions of 16 by 16 equivalent subapertures or more.

PHASE I: Conceptualize and design an innovative wavefront sensor and associated reconstruction scheme, and demonstrate in simulation that the design is attractive and feasible for operation in a high-scintillation, branch-point environment.. Plan a feasibility demonstration of the wavefront-sensing concept, and outline a sound set of demonstration success criteria. A design review will cover the sensing concept, it's implementation, and the data processing methods used to extract the deformable mirror phase from the sensor output.

PHASE II: Demonstrate the wavefront sensor concept developed in Phase I and show that it leads to continuous faceplate deformable mirror commands which improve strehl in imaging or laser projection systems. The offeror may test the concept at his/her facility, or, at the offeror's request, the AFRL may arrange to conduct test at the ABL Advanced Concepts Laboratory operated by MIT Lincoln Laboratory or at the Air Force Research Laboratory's Airborne Laser Advanced Concepts Testbed located at the White Sands Missile Range North Oscura Peak Facility. These facilities will be provided to the contractor at no cost to the contractor or the SBIR Program. It is expected that this phase will provide a new wavefront sensing method that is sufficiently validated to readily facilitate transition to systems such as the Airborne Laser and Relay Mirror.

PHASE III: Successful solution of the strong turbulence phase reconstruction problem would have widespread military application, including all military imaging or laser projection systems with requirements for precise atmospheric compensation through turbulent media. These applications include ABL, Relay Mirror, remote sensing, and atmospheric imaging programs.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The commercial market includes such areas as astronomy, communication, power beaming, and surveying.

REFERENCES: (1) D. L. Fried, "Least squares fitting a wave-front distortion estimate to an array of phase difference measurements," J. Opt. Soc. Am. 67, 1977, pp. 375-378. (2) D. L. Fried, "Branch point problem in adaptive optics," J. Opt. Soc. Am. A 15, pp. 2759-2768, October 1998. (3) G. A. Tyler, "Reconstruction and assessment of the least squares and slope discrepancy components of the phase," accepted for publication in J. Opt. Soc. Am. A, 2000 (in press). (4) M. C. Roggemann and A. C. Koivunen, "Branch-point reconstruction in laser beam projection through turbulence with finite-degree-of-freedom phase-only wave-front correction," J. Opt. Soc. Am. A 17, pp. 53-62, January 2000. (5) L. C. Andrews and R. L. Phillips, Laser Beam Propagation through Random Media, SPIE Optical Engineering Press, Bellingham, 1998.

KEYWORDS: adaptive optics; scintillation; branch points; wavefront reconstruction; wavefront sensing; beam control

MDA 03-021 TITLE: <u>Lightweight Innovative Composite Tank Concepts</u>

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: MDA/AL

OBJECTIVE: Develop lightweight composite tankage concepts for the Airborne Laser (ABL) Program. Develop innovative composite tankage design and fabrication methodologies that will reduce weight, be compatible to ABL fluid and gas media, and demonstrate an ability to resist microcracking when subjected to thermal and pressure cycling.

DESCRIPTION: The ABL Program is interested in the development of lightweight composite tanks as a means to reduce the overall mass of their system. The ABL system must contain a large amount of pressurized fluids, including several hundred gallons of cryogens. By utilizing composite tankage, the weight of these structures can be reduced by up to 40%. This reduction in weight directly translates to an additional payload margin of several thousand pounds. Additionally, lightweight composite tanks promise savings in cost, associated with their decreased need for touch labor and machining, which will help the program meet their budgetary goals. All composite tankage developed must be compatible to the ABL fluid or gas media being contained. The contractor is also encouraged to propose methodologies to prevent or resist composite laminate microcracking when thermal cycled. Another technology focus should be the tank boss regions. This region typically endures the highest leak rate due to its inherent complexity. The boss is typically made of aluminum, or another metal, and sealed against the composite structure of the tank. This typical material disparity frequently leads to inadequate sealing as a result of Coefficient of Thermal Expansion mismatches and differential strains. Contractors are encouraged to propose designs and fabrication methodologies that will eliminate the need for a tank boss, or somehow reduce the weight and complexity of this tank component substantially. Ease of manufacture, lower cost, less mass, media compatibility, and lower thermal conductivity and heat transfer to the contained fluids are all important to the ABL system.

PHASE I: Develop an ABL tankage concept to achieve at least one of the tank development objectives listed above. Identify the potential impact on critical parameters such as weight, cost, reliability, and performance. Develop a program plan that shall incorporate, but is not limited to, an ABL integration strategy/methodology for the new tank technologies. Determine system and subsystem level payoffs. Prepare a technical challenge report and risk mitigation strategy. Proof-of-concept hardware demonstrations including laminate coupon level testing are strongly encouraged.

PHASE II: Develop, fabricate, and test a prototype tank concept for the ABL Program as identified in Phase I. Conduct flight-qualification-like testing to validate the concept. Testing performed will gather data for a detailed performance analysis of the tank technology. Program success will be evaluated in accordance with ABL tank specifications, performance, and cost guidelines.

PHASE III: Both the military and the commercial space community stand to gain dramatically with the development of composite tankage. Reduced propellant system mass for ABL translates directly into increases in vehicle payload, range, speed, acceleration, and maneuverability. Composites also offer dramatic cost savings, because they do not require the extensive touch labor and machining required of similar metallic tank structures. Operational systems would gain considerably by utilizing the benefits associated with composites, this includes enhanced reliability and manufacturability.

PRIVATE SECTOR COMMERCIAL POTENTIAL: All commercial space systems (satellites, launch vehicles, aircraft, etc) that utilize tanks to contain gas and fluid media will benefit by utilizing all composite tanks in lieu of the 60% heavier metal configurations. Less mass means more payload, and better vehicle maneuverability. Composites have reduced life cycle costs relative to metallic structures.

REFERENCES: (1) Brandon J. Arritt, Eugene R. Fosness, Peter M. Wegner, and Jim Guerrero, “Composite Tank Development Efforts at the Air Force Research Laboratory Space Vehicles Directorate,” AIAA Space Conference & Exposition, Albuquerque, NM, August 2001. (2) David Whitehead, Brian Wilson, “Liquid Hydrogen (LH2) Tank Development Program”, Final Report AFRL-VS-PS-TR-1998-1021, May 1998.

KEYWORDS: Cryogenics; Lightweight; Advanced materials; Launch vehicles; Propellant tanks; Composites; Microcracking, Boss-less Composite Tanks, Composite Joining

MDA 03-022 TITLE: Lightweight Mirror Technology

TECHNOLOGY AREAS: Space Platforms, Weapons

ACQUISITION PROGRAM: MDA/AL

OBJECTIVE: Design and develop high-stiffness, ultra-lightweight, scalable mirror fabrication/production techniques.

DESCRIPTION: Current light-weighting approaches to mirror fabrication using glass-based substrates are limited in achieving an optimal solution to both structural and optical requirements. Primary considerations in mirror design are performance-based metrics such as optical performance in static and dynamic environments. Aperture weight and risk mitigation in fabrication, handling and polishing are usually relegated to a secondary design considerations. However, it is these secondary considerations that drive the cost of the item. Lightweight mirror production rates are exceedingly slow, with procurement times and costs that do not scale well with the mirror aperture. New technologies, such as nano-laminates, optically polished mandrels, better and faster polishing techniques and other technologies, have shown great promise at being able to meet performance based metric while making great strides in weight, cost and production times. High-structurally efficient mirror systems that cost less, can be made faster and have less fabrication risk are desired under this topic.

PHASE I: Investigation of advanced, high payoff approaches to high-structural efficiency mirrors is desired. The advantages of the approaches investigated with regards to structural efficiency, optical quality, manufacturability, producability, scalability, and environmental requirements should be demonstrated by analysis or historical data.

PHASE II: Finalize Phase I design and based on final design, develop a prototype component or system. Design and conduct laboratory demonstration based performance parameters derived from a military or militarily-relevant commercial application.

PHASE III: Due to the current high activity levels in both government and industry related to both the SBL and ABL programs, there are many opportunities for the advancement to a successful Phase-III program for this topic. Partnership with traditional DoD prime-contractors will be pursued towards this end. In addition, while government applications will receive the most direct and immediate benefit from a successful program, terrestrial optics also stands to benefit from the results of this program. In particular, high-structural efficiency steering mirrors could reduce complexity of any optical system with pointing requirements, including ground-based telescope applications, Printed Circuit Board photoetching systems, automatic identification systems, scanning and dimensioning systems, environmental & gaseous emission testing systems, Inspection mirrors, military & commercial aircraft mirrors, commercial and civilian remote sensing applications, and optical communications systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Commercial optics will benefit from the results of this program. In particular, ground-based telescope applications would be improved by in creasing the efficiency of the steering mirrors. They could also have an effect on Printed Circuit Board photoetching systems, automatic identification systems, scanning and dimensioning systems, environmental & gaseous emission testing systems, Inspection mirrors, military & commercial aircraft mirrors, commercial and civilian remote sensing applications, and optical communications systems.

REFERENCES:
1. Chen, P. C., et. al., "Advances in Very Lightweight Composite Mirror Technology," Opt. Eng., Vol. 39, pp. 2320-2329, September 2000.
2. Catanzaro, B., et. al., "C/SiC Advanced Mirror System Demonstrator Designs," UV, Optical, and IR Space Telescopes and Instruments, J. B. Breckenridge and P. J. Jakobsen, ed., Proc. SPIE Vol. 4013, pp. 672-680, 2000.
3. Safa, F., Levallois, F., Bougoin, M., and Castel, D., "Silicon Carbide Technology for Large Sub-millimeter Space-Based Telescopes," International Conference of Space Optics, ICSO97, Toulouse, December 1997.
4. Barbee, Troy; Wall, Mark A; “Interface reaction characterization and interfacial effects in multilayers”, Proc of the SPIE, Vol. 3133, p. 204-213, Grazing Incidence and Multilayer X-Ray Optical Systems.
5. Ulmer, Melville P.; Altkron, Robert I.; Graham, Michael E.; Madan, Anita; Chu, Yong S, “Production and performance of multilayer coated conic sections”, Proc. of the SPIE, Vol. 4496, p. 127-133, X-Ray Optics for Astronomy, Multi-Layers, Spectrometers, and Missions.

KEYWORDS: Lightweight; Mirrors; Manufacturing; Structures; Optics

MDA 03-023 TITLE: Precision High-Force Actuators for Adaptive Optics Mirror Shaping

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: MDA/AL

OBJECTIVE: To demonstrate technology for efficient nanometer-precise high-force actuators for shape control of adaptive optics mirrors for directed energy applications.

DESCRIPTION: Deformable mirrors development work has been employed to improve the quality of the wavefront of a projected beam or source image, which has been distorted by optical disturbances along the optical path. The military application is the delivery of a useful photon beam at a distance with good beam quality for illumination or lethality purposes. Actuator technology is needed to accomplish this deformation, but with power efficiency exceeding the state of the art while maintaining nanometer precision to accomplish optical surface shaping. The actuator motion must be stiff in the face of dynamic and thermal loads, while minimizing mass and volume of the device as well as the associated control and power electronics. There are both military and commercial uses for such devices, including Airborne Laser Systems (ABL). The state of the art for High Energy Laser (HEL) applications is a 32 x 32 actuator array around 10 inches in diameter capable of improving the wavefront with sufficient stroke to the order of a millisecond response. Flight applications may include the upper atmospheric environment and possible use under warfighting conditions. Integration with state-of-the-art deformable mirror materials is also important part of a proposal.

PHASE I: The respondent shall develop concepts and define the requirements for the design of an actuator with improved mass, volume, and power efficiency over state-of-the-art deformable mirror actuators. The conceptual design of a single actuator proof-of-concept prototype without form-factor electronics should be built and demonstrated in Phase I. The designs, a Phase I report including experimental data, and a proposal for Phase II will be expected products.

PHASE II: Detailed design and fabrication of a prototype with mature electronics and control schemes to be tested is expected. The contractor shall design appropriate characterization and performance tests to evaluate the prototype. These may include optical tests with a deformable surface. Scalability of the new design must be demonstrated and sufficient analysis performed to describe techniques for scaling. The final product is a complete test and characterization report of the new technology.

PHASE III: An immediate military customer is ABL. The likely dual use of this technology is a component technology for imaging sensor and astronomy applications.

REFERENCES:
1. Eugene R. Fosness, Waylon F. Gammill, and Steven J. Buckley, “Deployment and Release Devices efforts at the Air Force Research Laboratory Space Vehicles Directorate,” AIAA Space Conference & Exposition, Albuquerque, NM, August 2001.
2. Peffer, A., Fosness, E., Capt Hill, S., Gammill, W., and Sciulli, D., “Development and Transition of Low Shock Release Devices for Small Satellites,” presented at 14th Annual AIAA/Utah State University Conference on Small Satellites, Logan, Utah, Aug 23 – 26, 2000.

KEYWORDS: vibration isolation, structural dynamics, structural control, vibration suppression, high energy laser pointing

MDA 03-024 TITLE: Deformable Mirror (DM) Electronics Miniaturization

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: MDA/AL

OBJECTIVE: Develop designs and techniques to miniaturize the electronics for deformable mirrors.
DESCRIPTION: Present designs of DM electronics are heavy and require a significant amount of space in a standard electronics rack. These standard design consist of a single driver for each actuator. The intervening cable, that connects each driver to a single actuator, adds additional weight and becomes a mechanical short for the optics bench. These aspects of DM technology have to date not be considered restrictive. Most applications of DM's are in ground based systems. A ground based system does have restraints on rack space or weight. Additional racks can easily be accommodated and large, stiff structures can be used for cable routing, since weight is not an issue on the

ground. Applications in airborne and spaceborne systems, however, can not apply these standard methods and are forced to consider a more direct solution. Technology exists that can miniature an actuator driver to 7 cubic inches. The goal of 1 to 2 cubic inches per actuator driver could allow for the entire electronic package of a 256-actuator mirror to fit conveniently behind the DM faceplate. An associated weight of 2 ounce per actuator driver is also desirable for ease in mounting.

PHASE I: Provide the design of a DM actuator driver which can meet the goals of being packaged in 1 to 2 cubic inches of volume and weigh less than 2 to 3 ounces. The design is to consider heat removal which will become a significant issue with the dense packaging of all drivers behind the DM faceplate. The design is to be able to drive a lead, manganese, nyobate (PMN) actuator with a 4 micrometers amplitude sinusoidal signal at a 2 kHz rate with less than 3 degrees lag and at a 1 micrometer amplitude at a 10kHz rate with less than 50 degrees lag.

PHASE II: A subscale DM with miniaturized electronics is to be built and tested.

PHASE III: Application exists in ground based adaptive optics by making the secondary mirrors adaptive, diagnostics application in optometry and adaptive optics in airborne and spaceborne systems.

PRIVATE SECTOR COMMERCIAL WORKLOAD: Application exists in utilizing the diagnostics application in optometry.

REFERENCES: (1) Thomas Bifano, Micromechanical Arrays for Macroscopic Actuation of Deformable Mirrors, Boston University, 1996 (project code: memsact). (2) SPIE Proceedings Vol. 3126, Experimental demonstration of using microelectomechanical deformable mirrors to control optical aberrations, (paper #: 3126-19). (3) SPIE Proceedings Vol. 3126, Investigating a Xinetics Inc. Deformable Mirror (paper #: 3126-75).

KEYWORDS: Deformable Mirror Actuators; Deformable electronics Miniaturization;
Miniature Current Drivers; Low voltage DM actuators

MDA 03-025 TITLE: Advanced Processing of the Optical Surface on Large Lightweight Mirrors

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: MDA/AL

OBJECTIVES: To develop innovative, low cost, fast processes capable of producing an optical surface of visual quality on large mirror substrates for use in air borne and space based applications.

DESCRIPTION: The Air Force is seeking new and highly innovative concepts for reducing the cost and schedule of producing large, lightweight, segmented mirror systems (up to 10 meters in diameter) for both surveillance and directed energy applications. Traditional glass mirrors used in large telescopes are often very expensive and have very long production times mainly because of the labor intensive slumping, grinding, and polishing operations needed to produce the optical surface configuration. Near net shaping, grinding, and polishing of advanced metallic (Be or Si) and ceramic (SiC or Si_3N_4) based mirrors are even more time consuming because of inherent high hardness. The surface quality of a mirror is usually described by two parameters; (1) the precision of the geometrical shape/figure which should typically have an RMS value within 1/10 to 1/20 of the wavelength of light and (2) the surface micro-roughness, which contributes to scattering should to be on the order of 1/200 to 1/500 of a wavelength RMS. The stability of these quality parameters throughout the anticipated operational environment/life is also critical and must be understood. Print-through distortions caused by the mirror system geometry coupled with the differences or inhomogeneity in modulus and CTE of the various materials that make up a mirror system must be quantified to assure that the quality parameters remain within their specified acceptable ranges. New methods of producing the optical component/member to visual quality and maintaining it throughout the assembly stages shall be explored in this program. New or enhanced methods of contact and/or non-contact machining and polishing will be considered in this program if it can be shown to substantially reduce both cost and schedule compared to the current state of the art. Additionally, methods that eliminate the machining and polishing steps altogether will also be considered if it can be shown that they don’t re-introduce more processing steps with substantial cost and schedule penalties. Such processes could be either spinning a surface film of the desired quality onto a non-polished structural member or replicating the optical surface from a reusable polished mandrel followed by the buildup or attachment of the non-polished structural member prior to removal from the mandrel. In both cases a detailed discussion of the issues and impact of the bonding agents properties on the optical surface quality (including reliably and robustness) should be provided. The use of adhesives, solders, brazes or integral-bonding agents should be structurally compatible and stable with both the support and optical members under the anticipated operational conditions (ambient air or space with some heat loading). Desired material characteristics of the total mirror system include low density, high stiffness, low CTE in the operational range, high thermal conductivity, and high fracture toughness for vibration, impact, and heat-load damage control. Innovative methodologies and materials for the manufacturing of the optical member/surface and its attachment to the structural support member of a mirror system are sought.

PHASE I: Select and develop one or more materials, design approaches, and manufacturing processes for the optical member/surface of a mirror system. Develop estimates in terms of mass, cost, schedule, and performance parameters of this optical member when attached to the mirrors structural support member. Fabricate proof-of-concept coupon/sub-element components containing the optical member attached to the structural member and conduct preliminary performance testing necessary to aid in performance estimations. Suggest iterations to the mirror design, manufacturing methodology, and performance testing necessary to improve the scalability, while reducing cost and schedule without sacrificing performance.

PHASE II: Implement the manufacturing and test methodologies suggested in Phase I on a sub-element basis so that a down-selection to the optimum design/methodology is possible. Demonstrate the capability of this optimized process by fabricating at least a one-meter diameter primary mirror. Quantify the cost, schedule, and performance of the one-meter mirror with respect to the estimated parameters from Phase I. Produce a plan for demonstrating reproducibility and reliability of the one-meter mirror manufacturing process and provide a list of the limitations and problems expected in scaling up to a 3 to 4 meter mirror segment with the desired quality/performance.

PHASE III: DUAL-USE APPLICATIONS: Primary imaging and beam converging mirrors have a variety of DoD and commercial applications including land, air, and space based systems. Traditional mirror designs are heavy, costly, and very time intensive to manufacture. Demonstration of a lightweight, low cost, fast manufacturing method would provide tremendous savings and capability enhancement for future aircraft and spacecraft missions requiring these types of mirrors.

REFERENCES:
1. Carlin, P. S., "Lightweight Segmented Mirror Systems for Spacecraft", Proceedings of the IEEE Aerospace Conference, 18-25 March 2000, Big Sky, Montana.
2. Wilson, R. N., Reflecting Telescope Optics I, Springer-Verlag, New York, 1996.
3. Wilson, R. N., Reflecting Telescope Optics II, Springer-Verlag, New York, 1999.

KEYWORDS: Adaptive Optics; Replicating Optical Surfaces; Micromachining Optical Surfaces; Deformable Mirror; Space Based Laser Wavefront Control; Segmented Mirrors; Airborne Laser Wavefront Control

MDA 03-026 TITLE: Ultra-Lightweight Large-Aperture, SiC Optical Components

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: MDA/AL

OBJECTIVE: To dramatically reduce cost, schedule, and weight for large-aperture optical systems via use of Silicon Carbide for mirror backing structures and optical substrate.

DESCRIPTION: Numerous government agencies have defined needs for large, lightweight optical systems. Ongoing programs, are directed at dramatically reducing cost, schedule, and weight for large-aperture optical systems through emphasis on use of advanced design and integration techniques. Preliminary results have shown the potential for further stiffness and unit mass improvement via use of advanced manufacturing techniques that employed advanced thermally stable materials such as Silicon Carbide for mirror backing structures and optical substrate. For the proposed effort, the contractor shall select a valid optical system architecture concept for application of advanced SiC for backing structures and optical substrate. Cost estimates to acquire any necessary facilities to fabricate, assemble, and test a full optical system (prime contractor concept) of the proposed technology must be provided. In addition, the contractor shall provide the cost data showing the cost benefits, choose a optical system architecture design for detailed manufacturing analysis, describe their approach for accommodating mirror deformation from coating stresses, thermal loading (absorption of solar and/or laser irradiation), and the costs associated with these modifications through their manufacturing analysis. The proposal shall provide test data to support their coating selection that addresses issues such as solar absorptance and traceability analysis.

PHASE I: The offeror is expected to produce a detailed design that will achieve the architecture goals and show traceability to a valid deployable optical system.

PHASE II: This effort will fabricate, assemble, and test a prototype mirror system. The offeror must demonstrate that the ambient mirror system can be used for visible-wavelength applications. If a single mirror is selected under ambient and/or cryogenic requirements, the mirror will be required to meet the ambient requirements and undergo the necessary modifications for cryogenic testing under this Phase if the cryogenic option is chosen.

PHASE III: It is anticipated that successful demonstration of Phase II goals will lead to commercialization of this technology for low cost imaging systems and incorporation in laser cross-link communications.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This will give corporations with remote sensing better imagery or an increased capability to cross link communications.

REFERENCES: (1) T. T. Saha, D. B. Leviton, and P. Glenn, “Performance of ion-figured silicon carbide SUMER telescope mirror in the vacuum ultraviolet,” Applied Optics, Vol. 35, No. 10 (April 1996). (2) E. L. Church and P. Z. Takacs, “Specification of surface figure and finish in terms of system performance,” Applied Optics, Vol. 32, No. 19 (July 1993). (3) R. R. Shannon, The Art and Science of Optical Design, Cambridge University Press (1997).

KEYWORDS: optics; large-aperture; lightweight; silicon carbide

MDA 03-027 TITLE: <u>Beam Control for Extended Range</u>

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: MDA/AL

OBJECTIVE: Demonstrate innovative methods for adaptive optics and tracking for an airborne platform addressing fast long-range targets that may be at high altitude.

DESCRIPTION: There is interest in the propagation of laser beams over long atmospheric paths. A primary system of interest is the Airborne Laser (ABL). ABL missions typically require operation in high scintillation environments that greatly complicate the tracking and adaptive optics tasks. In designs, the track beacon gathers information for pointing, and a separate adaptive optics beacon gathers information for adaptive optics. With the two beacons, the anisoplanatic hit can be taken in the tilt loops, whereas the adaptive optics beacon is placed on the missile body so that the higher order loops run on isoplanatic information. The reason for this separation is that tilt anisoplanatism is more forgiving than higher order anisoplanatism. Tilt anisoplanatism is then set by the aimpoint position relative to the nose.

The targets of interest for this SBIR are at longer ranges (on the order of 1,000Km) and are moving at higher speeds (several Km/s) than those that gave rise to the above family of designs. Applicable Rytov numbers range from 0.1 for very high targets up to 1.0 for lower elevation targets. due to the speed and range of many of these targets the adaptive optics beacon would have to be placed ahead of the missile body in order for the incoming sensed information to be isoplanatic with the pointing direction. This clearly doesn't work. Thus this solicitation seeks beam control designs that accommodate this situation which may use relay technology techniques. Specifically, there appear to be several beacon approaches for the adaptive optics loops: 1 use the nose beacon for both adaptive optics and for tracking; 2 use a guidestar for the adaptive optics loops.

For case 1 the adaptive optics information is from the wrong direction, thus some sort of estimation, adaptive perhaps, will be required for best performance. On the other hand one now has wavefront sensor information from the nose. This may be useful, together with the tracker information, in more optimally pointing the beam. For case 2 the guidestar beacon can be placed in the right direction, obviating directional anisoplanatism in the higher order loops. However, one now has to contend with focus anisoplanatism as well as signal to noise issues. In either case there are additional problems to overcome, but also some additional opportunities. Perhaps non-linear phase reconstruction plus estimation may play a role. Perhaps combining wavefront sensor and tracker information with guidestar information might prove both practical and beneficial.

This solicitation seeks innovative solutions to the above-described challenges. Most desirable is a concept that would address the total problem. However the government will consider concepts addressing tracking only or adaptive optics only,

PHASE I: Conceptualize a solution, considering relay technology techniques, to one or more aspects of the beam control problem for the fast, long-range targets of interest. A design review will cover the concept, it's proposed implementation, and simulation or analytical validation of the approach.

PHASE II: Demonstrate the concept developed in Phase I through further simulation as well as in hardware. The simulation will be a full wave optics simulation that is representative of the types of systems and scenarios of interest to the Air Force. The hardware demonstration should be done at the AFRL Advanced Concepts Laboratory at MIT Lincoln Labs.

PHASE III: Successful demonstration of a concept for improving beam control performance in the scenarios of interest will be transitioned to the ABL SPO for incorporation in future ABL like systems.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: Solutions of tracking and adaptive optics in an aberrating environment have already found applications in the medical imaging community. The enhanced solutions called for here should extend current applications to even more difficult medical imaging problems.

REFERENCES:
1. Andrews, L. C. and R. L. Phillips, Laser Beam Propagation through Random Media, SPIE Optical Engineering Press, Bellingham, 1998.
2. Fields, M. H. and J. E. Kansky, P. J. Berger and C. Higgs, “Initial Results for the Advanced-Concepts Laboratory for Adaptive Optics and Tracking,” Proc. of SPIE, April 2000.
3. Gibson, J. S., C.-C.-Chang, and B. L. Ellerbroek, “Adaptive optics: correction by use of adaptive filtering and control,” Applied Optics, Optical Technology and Biomedical Optics, No. 16, p. 2525.
4. Merritt, P., Cusumano, et. al. "Active Tracking of a Ballistic Missile in Boost Phase", Proceedings of SPIE, ATP, 2739, 1996.
5. Roggemann, M. C., and Welsh, B, Imaging through Turbulence, CRC Press, New York, 1996.

KEYWORDS: adaptive optics, scintillation, wavefront reconstruction, wavefront sensing, tracking, beam control, estimation, guidestar

MDA 03-028 TITLE: Electron Bombarded Charge Coupled Device (EBCCD)

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: MDA/AL

OBJECTIVE: Develop EBCCD's with frame rate of 10hZ and provides a gain of 200 which would boost the photon shot noise above all other detector and readout noise sources.

DESCRIPTION: The state of the art Electro bombarded charge coupled device has no proven reliability. This sensor resolves the illuminated hard body to determine the High energy laser and Beacon illuminator aim point and to measure atmospheric jitter, also to avoid latency in the control loop, an EBCCD frame rate of 10hZ is required to provide adequate sample time for data transfer and processing.

Improve reliability of their photodiodes with reliability growth testing of the EBCCD's. This would ensure that the EBCCD provides a gain of 200 which would boost the photon shot noise above all other detector and readout noise sources and provide photon limited detection of the illuminator signal returned by the target for maximum SNR. This reliability improvement will reduce maintenance burden on all systems employing a fine tracker concept, improve specifications for procuring EBCCD's and improve maintenance process and reduce operating and support costs.

PHASE I: Define the proposed system concept, specific system requirements, and predict the performance of the proposed design. Demonstrate basic system concepts in a laboratory environment.

PHASE II: Provide a prototype component or system and laboratory demonstration to mutually agreed performance parameters. Demonstration EBCCD (Sensor) must be capable to support ground demonstration in a government facility and be qualifiable for an airborne experiment. The prime consideration must be deliverable system hardware and a clear demonstration of the integrated high-performance system that will demonstrate a 20-year lifetime.

PHASE III: There is tremendous growth in the use of sensors in both space and airborne applications. With this increase along with requirements of ABL and SBL a requirement is created for an effective EBCCD with high frame rates and low noise. It is expected such a system will find an abundance of applications in the commercial and defense sectors.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Biomedical imaging and photonic systems are some of the dominant potential users of this technology.

REFERENCES: (1) R.G. Hier, W. Zheng, E.A. Beaver, C.E. McIlwain, and G.W. Schmidt, "Development of a CCD-Digicon detector system," Advances in Electronics and Electron Systems Vol. 74, pp. 55-67, Academic Press, 1988. (2) J.C. Richard, L. Bergonzi and M. Lemonier, "A 604x288 Electron-bombarded CCD image tube for 2D photon counting", SPIE Vol 1338 Optoelectronic Devices and Applications, pp. 241-54, 1990. (3) W. Enloe, R. Sheldon, L. Reed and A. Amith, "An electron-bombarded CCD image intensifier with a GaAs photocathode," SPIE Vol 1655 Electron Tubes and Image Intensifiers, pp. 41-49, 1992. (4) J.C. Richard, D. Riou and M. Vittot, "Low-light-level TV with image intensifier tubes and CCDs", Advances in Electronics and Electron Physics Vol. 74, pp. 9 -15, Academic Press, 1988. (5) G.I. Bryukhnevitch, et. al., "Picosecond image converter tubes incorporated with EB CCDs readout," SPIE Vol 1655 Electron Tubes and Image Intensifiers, pp. 94-105, 1992. (6) M. Dunham and P. Sanchez, "Ultimate sensitivity and resolution of phosphor/fiber/charge-coupled-device system," Optical Engineering, Vol. 26 No. 10, pp. 1035-1042, Oct 1987. (7) J.C. Cheng, G.R. Tripp and L.W. Coleman, "Intensified CCD readout system for ultrafast streak cameras," J. Applied Physics, Vol. 49, No. 11, pp. 5421-5426, Nov. 1978. (8) T. Daud, J. Janesick, K. Evans and T. Elliott, "Charge-coupled-device response to electron beam energies of less than 1 keV up to 20 keV," Optical Engineering, Vol. 26 No. 8, pp. 686-691, Aug. 1987. (9) W. van Roosbroeck, "Theory and yield and Fano factor of electron-hole pairs generated in semiconductors by high energy particles," Physical Review, Vol. 139 No. 5A, pp. A1702-16, Aug. 30, 1965. (10) M.K. Ravel and A. Reinheimer, "Backside-thinned CCDs for keV electron detection," SPIE Proceedings Vol 1447-10, Feb. 1991.

KEYWORDS: Electron Bombarded Charge Coupled Device; sensors; frame rates; signal to noise ratios; EBCCD.

MDA 03-029 TITLE: Data Driven Prognostics

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: MDA/AL

OBJECTIVE: Develop a data driven prognostic system based on pattern recognition technologies that provides advanced warning of failure, fault and other error events.

DESCRIPTION: Computer controlled machines/equipment continually generate operating data, such as sensor logs, command logs, activity logs and error code logs, that act as a record their operating history. Such data can be represented mathematically to describe the state of a machine at a point in time. A functioning machine creates a dataset in n-dimensional space containing certain, recognizable signatures, whilst a malfunctioning machine generates different data and creates different signature sets with each signature being specific to a particular condition or event. These signatures are separated by complex partitions in the n dimensional dataset.

The objective of the project is to develop and demonstrate a library of predictive engines based on a number of advanced pattern recognition techniques and mathematical algorithms - such as generic algorithms, multivariate statistics, theories of chaos, topology, neural networks, signal analysis and mathematical logic - which identify the partitions that separate the early signatures of functioning machines from those later signatures of malfunctioning machines, thereby allowing the prediction of specific machine or system malfunctioning events prior to their occurrence.

Once defined, the predictive engines will be ported to an automated processing environment, where operational machine data will be sent electronically to a remote processing facility where it will be analyzed to provide advanced warning of specific failure, fault and error events.

PHASE I: A mapping process will be created to define target events for prediction, based on a value set that includes cost and safety considerations. In conjunction, available historical data will be analyzed in a preliminary assessment of the adequacy of the existing dataset for prediction.

PHASE II: Using historical operational machine data, their transforms and error code mapping, an initial group of predictive engines will be developed for target events. These predictive engines will then be refined for accuracy using live machine data sets, and demonstrated in a test field environment

PHASE III: An automated solution for data integration, transformation, and prediction will be established. The resulting prognostic system will be deployed across the identified fleet population and further refined for predictive capability and to expand the target event base.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The ability to predict machine/equipment events has significant commercial potential in aircraft, power, manufacturing, processing, transportation, and other industrial applications where such capability would allow companies to improve reliability and safety, reduce downtime, and lower the direct maintenance cost of physical assets.

REFERENCES: (1) Artificial Intelligence in Equipment Maintenance and Support: Papers from the 1999 AAAI Spring Symposium, Technical Report SS-99-04, ISBN 1-57735-081-2.
(2) 2001 IEEE Aerospace Conference Proceedings. Track 11: Diagnostics, Prognostics, and Health Management. IEEE Catalog Number 01TH8542C, ISBN 0-7803-6600-X.

KEYWORDS: multivariate statistics, theories of chaos, topology, neural networks, signal analysis and mathematical logic, Prognostics

MDA 03-030 TITLE: <u>Multifunctional Structures for Aerospace Applications</u>

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: MDA/AL

OBJECTIVE: Reduce mass and volume of DOD weapon systems through use of Multi-Functional Structures (MFS) technology.

DESCRIPTION: Current state-of-the-art for aerospace vehicle electronic configurations use heavy cumbersome cabling and connectors. These components compose a significant portion of the mass of the aerospace vehicle, require a large amount of touch labor to manufacture, have a limited test/monitoring capability, are difficult to install in the vehicle, and require significant support brackets. The avionics boxes are connected together by conventional round wire cable bundles that are touch-labor intensive to manufacture due to the many individual manual solder connections that are necessary at each connector node. These cables are composed of a bundle of individual wires bound together with mechanical bindings, attached to the aerospace vehicle structure with various high-strength mechanical brackets and tie-downs, and finished on each end with complex and expensive connectors. These cables are difficult to install and do not precisely conform to structural curvatures. The avionics boxes are large and do not smoothly integrate with the vehicle structure and cabling. Additionally, the cables, once installed, have limited test/monitoring capabilities. For example, the flight-ready configuration must be compromised and the cables disconnected in order to troubleshoot for electrical discontinuities. The Air Force is looking for new innovative ideas to integrate the load carrying capability of traditional structures with the cabling requirements of aerospace vehicles. The basic approach is to reconfigure the cabling to improve the way they integrate into the aerospace vehicle structure, minimize mass and volume requirements, and to simplify the cabling manufacturing process. The proposal should address solutions for these issues and should focus on flexible circuitry, high density interconnects, and multichip module technologies. The technologies proposed should address thermal management of the electronic subsystems, while not sacrificing maintainability of these systems before or after integration onto the aerospace vehicle. A collaborative effort with the aerospace vehicle manufacturer is encouraged to facilitate integration and demonstration of the technologies proposed.

PHASE I: Develop and design a concept that will replace an aerospace vehicle electronics system. Provide a proof-of-concept demonstration of proposed technology. Perform an impact analysis of technology on proposed system. A strategy to transition the technologies developed for existing and future aerospace vehicles are strongly encouraged

PHASE II: Develop and demonstrate prototype hardware for the concept identified in Phase I. Tasks shall include a detailed proof of concept demonstration of key technical parameters that can be accomplished at a subscale level and a detailed performance analysis. In addition, develop a program plan that shall incorporate an implementation strategy/methodology, a detailed technical challenge breakdown, risk mitigation strategy, potential flight demonstration opportunities, proposed program schedule, and estimated costs. .

PHASE III DUAL USE APPLICATIONS: Both the military and the commercial sector stand to gain with the replacement of conventional round wire cable with new innovative cabling technologies that integrate the development of MFS technologies. If successful, this technology could provide a new design paradign for aerospace cabling that could lead to substantial mass, volume, and cost savings at the system level. For example, the reduction of touch labor associated with build-up, rework, inspection, and testing is a substantial cost of the overall system level expense associated with aerospace vehicles. This capability will be very attractive to both military and commercial aerospace vehicle managers.

REFERENCES :
1. “Multifunctional Structures”, presented at the AIAA Space 2001 Conference in Albuquerque, NM, 28-30 August 2001.
2. “Design & Testing of Multifunctional Structure Concept”, presented at the 41st Annual Structural Design and Materials AIAA and ASME Conference, 4 April 2000, Atlanta, GA.
3. “Multifunctional Structures Technology Demonstration on NMO Deep Space 1”, presented at the Deep Space 1 Technology Validation Symposium, 9 February 00, Pasadena, California.
4. “Overview of Multifunctional Structure Efforts at the Air Force Research Laboratory”, presented at the Space 2000 & Robotics 2000 Conference, Albuquerque, NM 28 February 1999.

KEYWORDS: Multichip module, Flexible circuitry, Multifunctional structures, Modular avionics, Aerospace vehicles, Spacecraft, Cabling, Structures

MDA 03-031 TITLE: Advanced Chemical Iodine Lasers

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: MDA/AL

Objective: Demonstrate innovative concepts relevant to the development of a high-energy chemical iodine laser.

Description: The Air Force Research Laboratory's Directed Energy Directorate (AFRL/DE) is interested in promoting and conducting innovative research on promising new technologies relevant to the development of high-energy chemical iodine lasers. The most common chemical iodine laser, COIL (Chemical Oxygen Iodine Laser), uses the highly efficient reaction between molecular chlorine and basic hydrogen peroxide (BHP) to generate electronically excited (singlet delta) oxygen. Singlet delta oxygen reacts via electronic energy transfer with atomic iodine to produce a population inversion on the I*(2P1/2) - I(2P3/2) spin-orbit transition. Provided that sufficient gain can be achieved, single line lasing at 1.3 microns is the result of the energy transfer process. Similarly, the All Gas-phase Iodine Laser (AGIL) produces singlet delta NCl that also reacts with atomic iodine to produce a population inversion.

Unfortunately, traditional COIL devices require the use of highly corrosive and bulky liquid reagents (eg. BHP) and current AGIL concepts use hydrogen azide (HN3) a highly toxic and explosive gas. These features are troublesome for both airborne and space-based applications and AFRL/DE is seeking alternative methods for generating singlet delta oxygen and/or NCl.

Potential sources of electronically excited O2 and NCl include electric discharges, alternative chemical mechanisms, optical pumping schemes, or other efficient energy transfer processes. Proposed concepts must be capable of producing high number densities of singlet delta O2, NCl, or another acceptable energy carrier.

Phase I: 1) Define and model a promising chemical iodine laser concept or energy carrier generator. Or 2) investigate issues related to the production, storage, and usage of high densities of hydrogen azide or an alternative source of singlet delta NCl. Identify and investigate the key physical or chemical processes and arrive at a design concept.

Phase II: Continue the effort initiated in Phase I. Design, construct, and carry out the key experiment(s) identified in Phase I. Generate an engineering design for a full scale device. Where appropriate, construct and demonstrate the full-scale device.

Phase III: Possible applications include nuclear reactor decommissioning, robotic welding, and mining / drilling.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Possible applications include nuclear reactor decommissioning, robotic welding, and mining / drilling.

References: (1) Gerald C. Manke II and Gordon D. Hager, "Advanced COIL - Physics, Chemistry, and Uses," J. Mod. Opt., accepted, 2001. (2) Thomas L. Henshaw, Gerald C. Manke II, Timothy J. Madden, Michael R. Berman, and Gordon D. Hager, "A New Energy Transfer Laser at 1.315 microns," Chem. Phys. Lett., Vol. 325, pp. 537- 544, 2000.

KEYWORDS: Chemical lasers; Directed energy weapons; Lasers; Space based lasers; Airborne lasers

MDA 03-032 TITLE: Lightweight Low Contamination Materials

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: MDA/AL

OBJECTIVE: Develop lightweight, low contamination materials for Absorption of high-energy laser beams.

DESCRIPTION: High-energy laser systems require laser beam absorption Materials that can be placed in the beam to provide beam shaping, control, and dumping. A laser needs to have lightweight materials that will not melt, change dimensions or contaminate the laser system when exposed to the high-energy laser beam. Such materials should be environmentally robust, machineable and dimensionally stable over normal military specification ranges (-40 to 60 C). After exposure to a high-energy laser they should not lose appreciable amounts of mass, less then 0.01 percent mass loss as a goal. These materials should have high heat capacity and resistance to pulsed and continuous wave laser damage, estimated levels would be in excess of 15 J/cm2 and 10 kW/cm2. Other useful features of the new material would be high (greater than 0.99) absorption and low reflectivity (less than 0.01).

PHASE I: Deliver small-scale test coupons ready for testing to determine their energy-absorption characteristics. These coupons would also be tested for their laser-damage resistance, mass loss, and reflectivity properties. It is also possible that coupons will be subjected to atomic oxygen and ionizing radiation, to determine if they are qualifiable for space application.

PHASE II: Deliver full-scale shaped material ready for testing to determine their energy-absorption characteristics. At this point, the materials would be subject to full-scale qualification for flight, with all the structural material and optical properties, remeasured.

PHASE III: Materials of this type will be of use on Air Borne Laser (ABL) and the ABL Engineering, Manufacturing, and Development (ABL EMD), for lightweight safety dumps, the Tactical High Energy Laser (THEL) and follow ons, and the SBL.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Use of light-weight material with the above properties will be of use in laser beam shaping and control materials for any industrial application and could be of use as insulation and nonablative shielding materials for use in jet and rocket engines and commercial furnaces.

REFERENCES: (1) Gerald C. Manke II and Gordon D. Hager, "Advanced COIL - Physics, Chemistry, and Uses," J. Mod. Opt., accepted, 2001. (2) Thomas L. Henshaw, Gerald C. Manke II, Timothy J. Madden, Michael R. Berman, and Gordon D. Hager, "A New Energy Transfer Laser at 1.315 microns," Chem. Phys. Lett., Vol. 325, pp. 537- 544, 2000.

KEYWORDS: Chemical lasers; Directed energy weapons; Lasers; Space based lasers; Airborne lasers

MDA 03-033 TITLE: <u>Ballistic Missile Fuel Tank Ullage Fire/Explosion Modeling</u>

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: MDA/AL

OBJECTIVE: Model laser interaction with ballistic missiles to determine the interplay between fuels and heated missile walls.

DESCRIPTION: High power lasers are currently in development that are designed to engage ballistic missile during there active boost phase. These weapons systems are designed to engage the pressurized propellant tank or motorcase of the missile, causing it to fail in a catastrophic manner. While the baseline failure mechanism is well characterized1, there are many factors that can cause enhancements to the lethality of weapons system against the missiles. One such factor is fuel ignition that leads to additional damage to the missile. Fuels used in many common aircraft application2 have been characterized and various models handling ballistic impact on these fuel tanks have been developed3. However, there exists a deficiency in the availability of detailed numerical models for the laser/missile fuel tank interaction.

PHASE I: Research current state of the art combustion modeling and develop a first principle model that handles the geometry and environment of a ballistic missile that has been vented by a laser weapon. The initial model should be able to handle a single tank geometry and fuel type as well as a limited number of engagement conditions (altitude and missile velocity). All relevant physics should be accounted for, including reaction kinetics, aerodynamic, and heat transfer to between the heated missile wall and combustible fuel.

PHASE II: Carry the model development to a working level that includes user-specified geometries, additional propellant types, greater rage of engagement conditions, user-friendly interface. Model should be validated against test data collected against geometries and fuels of interest.

PHASE III: Commercial launch vehicle reliability analysis, Aircraft safety. The developed model would have additional military application in analysis of the Space Based Laser lethality analysis as well as a tool for system hardening of domestic missile.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This can be used for Commercial launch vehicle reliability analysis, Aircraft safety

REFERENCES: (1) J. Beraun, et al., " Airborne Laser Lethality Test Series, Volume I of II Subscale and Half Scale Targets," PL-TR-96-1051, Vol. I, Phillips Laboratory, KAFB, NM, June 1996. (Unclassified). (2) T. B. Biddle, et al., "Properties of Aircraft Fuels and Related Materials," WL-TR-91-2036, Wright Labs, WPAFB, Ohio, July 1991. (Unclassified). (3) A. M. Pascal, "Ullage Explosion Model Source Code Description," SURVIAC-TR-97-024, 1997. (Unclassified)

MDA 03-034 TITLE: Gallium Nitride (GaN) Device Technology Enhancements Leading to Advanced Transmit/Receive (T/R) Modules for Radar Performance Enhancement

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: MDA/GM

OBJECTIVE: Develop and demonstrate Gallium Nitride (GaN) device technologies that contribute to the development of GaN-based high power amplifiers and Transmitter/ Receiver (T/R) modules for incorporation in X-Band Ballistic Missile Defense (BMD) class radars, with increased power, bandwidth, and power added efficiency exceeding performance attainable with state of the art Gallium Arsenide (GaAs) modules.

DESCRIPTION: Enhanced performance (improved resolution, enhanced discrimination, and increased power) of BMD X-Band Radars may be achieved by incorporating Transmit/ Receive (T/R) modules that use power amplifiers composed of multiple GaN based transistors capable of 30 Watts of power per module operating through 10 GHZ. Individual transistors should achieve power added efficiencies of 40-50% and power amplifiers should achieve power added efficiencies on the order of 25%. Device power, efficiency, and bandwidth should not degrade significantly over extended periods of peak power operation. Novel power amplifier and device designs, materials processing and production methods, and device cooling are anticipated. Current GaN High Electron Mobility Transistors (HEMTs) change performance over time at temperature. Performance-enhancing techniques such as gate recess are not established for GaN-based devices. GaN HEMTs should not show significant degradation in power, efficiency, or bandwidth over long periods of operation at peak power levels when the channel temperature does not exceed 150 C.

PHASE I: Analyze, design, and conduct proof-of-principle demonstrations of advanced GaN based devices (HEMTs, Power Amplifiers, T/R modules) or technologies leading to the production of these devices.

PHASE II: Develop and demonstrate prototype devices (power transistors, amplifiers, T/R modules) that demonstrate stable device performance and meet or exceed the power, efficiency, bandwidth, and degradation goals. Develop and demonstrate new processes (or hardware) that lead to production improved devices.

PHASE III: Prepare detailed plans to implement demonstrated capabilities on critical military and commercial applications. Produce production quality HEMTs, power amplifiers, T/R modules, or devices that lead to the production of said components.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: Advanced GaN based HEMTs and power amplifiers have application throughout commercial industries. Commercial radars, communications equipment, cell phones, and satellites, would benefit from this development.

REFERENCES:
1. http://nsr.mij.mrs.org/
2. http://nina.ecse.rpi.edu/shur/Tutorial/GaNtutorial2/index.htm

KEYWORDS: GaN Power Amplifiers; GaN transistors; Radar; Transmit/Receive Module; X-band; GaN based materials processing; gate recess

MDA 03-035 TITLE: Technologies Enabling Active Multi-Mode Exo-atmospheric Seeker Based on Range-Resolved Doppler Imaging LADAR and Passive Multi-Color LWIR detection.

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: MDa/GM

OBJECTIVE: Develop advanced active seeker based on Range-Resolved Doppler Imaging Laser Radar (LADAR) and Passive Multi-Color LWIR detection for incorporation in an Exo-atomospheric Kill Vehicle (EKV) to improve target detection, discrimination and aimpoint selection.

DESCRIPTION: An active seeker would provide enhanced target detection, on-board discrimination and improved end-game guidance for hit-to-kill interceptors. Technologies that enable Range-Resolved Doppler Imaging Laser Radar (LADAR) to achieve higher transmitted energy levels, faster waveform processing, better beam quality, higher pulse repetition rate, enhanced efficiency, greater revisit rates, improved sensitivity, and increased reliability, while conforming to the mass, volume, and power constraints of an EKV are critical to the optimal performance of this technology. Combination of the LADAR with a multicolor IR seeker would provide a three-dimensional imaging capability that would reduce or eliminate dependency on a priori data for aimpoint selection.

PHASE I: Design, fabricate and provide proof-of-principle demonstrations of advanced seeker sensor technologies.

PHASE II: Develop prototype seeker systems and demonstrate these in a simulated flight environment. These tests should include environmental testing to ensure reliable operation in a stressing, realistic operational environment.

PHASE III: Integrate seeker technology into interceptor designs for incorporation in block upgrades.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: The sensor technologies being developed in this effort will have dual application in law enforcement and for material processing to detect material defects.

REFERENCES:
1. Jelalian, A.V., Laser Radar Systems, Artech House, Norwood House, MA, 1992.
2. http://web.cas-inc.com/divs/AMOR/data_examples.html
3. HgCdTe photodiodes for IR detection: a review; Reine, Marion B.; Proc. SPIE Vol. 4288, p. 266-277.
4. Dual-band infrared focal plane arrays; Rogalski, Antoni; Proc. SPIE Vol. 4340, p. 1-14.
5. Simultaneous MW/LW dual-band MOVPE HgCdTe 64x64 FPAs; Reine, Marion B., et. al.; Proc. SPIE Vol. 3379, p. 200-212.

KEYWORDS: Seeker; Multicolor Focal Plane Array; LADAR; MWIR; LWIR; VLWIR; waveform processing; Coherent LADAR

MDA 03-036 TITLE: Technologies Enabling Active Multi-Mode Exo-atmospheric Seeker Based on Angle-Angle Range Imaging LADAR and Passive Multi-Color LWIR detection

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: MDA/GM

OBJECTIVE: Develop advanced active seeker based on Angle-Angle Range Imaging Laser Radar (LADAR) and Passive Multi-Color Long Wave Infrared (LWIR) detection for incorporation in an Exo-atomospheric Kill Vehicle (EKV) to improve target detection, discrimination and aimpoint selection.

DESCRIPTION: An active seeker would provide enhanced target detection, on-board discrimination and improved end-game guidance for hit-to-kill interceptors. Technologies that enable Angle-Angle Range Imaging Laser Radar (LADAR) to achieve higher transmitted energy levels, better beam quality, higher pulse repetition rate, enhanced efficiency, greater revisit rates, improved sensitivity, and increased reliability, while conforming to the mass, volume, and power constraints of an EKV are critical to the optimal performance of this technology. Combination of the LADAR with a multicolor IR seeker would provide a three-dimensional imaging capability that would reduce or eliminate dependency on a priori data for aimpoint selection.

PHASE I: Design, fabricate and provide proof-of-principle demonstrations of advanced seeker sensor technologies.

PHASE II: Develop prototype seeker systems and demonstrate these in a simulated flight environment. These tests should include environmental testing to ensure reliable operation in a stressing, realistic operational environment.

PHASE III: Integrate seeker technology into interceptor designs for incorporation in block upgrades.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: The sensor technologies being developed in this effort will have dual application in law enforcement and for material processing to detect material defects.

REFERENCES:
1. Jelalian, A.V., Laser Radar Systems, Artech House, Norwood House, MA, 1992.
2. http://web.cas-inc.com/divs/AMOR/data_examples.html
3. HgCdTe photodiodes for IR detection: a review; Reine, Marion B.; Proc. SPIE Vol. 4288, p. 266-277.
4. Dual-band infrared focal plane arrays; Rogalski, Antoni; Proc. SPIE Vol. 4340, p. 1-14.
5. Simultaneous MW/LW dual-band MOVPE HgCdTe 64x64 FPAs; Reine, Marion B., et. al.; Proc. SPIE Vol. 3379, p. 200-212.

KEYWORDS: Seeker; Multicolor Focal Plane Array; LADAR; MWIR; LWIR; VLWIR

MDA 03-037 TITLE: Advanced In-Flight Interceptor Communications System (IFICS) Error Detection/Correction

TECHNOLOGY AREAS: Information Systems, Weapons

ACQUISITION PROGRAM: MDA/GM

OBJECTIVE: Improve In-Flight Interceptor Communication System (IFICS) performance to enhance probability of message delivery in adverse conditions.

DESCRIPTION: Improve IFICS performance by means of optimized error detection/ correction methods that permit more robust communication in nuclear or jamming environments. Recent developments in coding theory, particularly Turbo Codes, have the potential to significantly improve link performance. This SBIR seeks to improve link performance by optimizing error detection/correction algorithms in Rayleigh and Rician fading channel conditions as produced by nuclear weapons effects in the ionosphere. These algorithms may be implemented in the form of software and/or application specific integrated circuits.

PHASE I: Conduct research and experimental efforts to demonstrate proof-of-principle of the proposed technology. Measure and report performance improvements over current state-of-the-art.

PHASE II: Demonstrate flight readiness of technology. Fabricate and test prototype hardware/software. Demonstrate applicability to both selected military and commercial applications.

PHASE III: Insert this technology into future Ballistic Missile Defense systems such as the GMD interceptor. Adapt this technology to commercial markets.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technology may have commercial and industrial application in remote operations and airline communications.

REFERENCES:
1. Performance Evaluation of Superorthogonal Turbo Codes in AWGN and Flat Rayleigh Fading Channels by Petri Komulainen and Kari Pehkonen, IEEE Journal on Selected Areas in Communications, Vol. 16, No. 2 Feb. 1998.
2. A Conceptual Framework for Understanding Turbo Codes, by Gerard Battail, IEEE Journal on Selected Areas in Communications, Vol. 16, No. 2 Feb. 1998.

KEYWORDS: error correction; error detection; missile communications; turbo codes; fading channels.

MDA 03-038 TITLE: Advanced Signal/Data Processing Algorithms

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: MDa/GM

OBJECTIVE: Develop advanced signal/data processing algorithms to enhance the acquisition, tracking, and discrimination of a target object in high clutter environments. These algorithms will increase probability of detecting lower cross section targets while reducing the bandwidth necessary for discrimination.

DESCRIPTION: The state of the art algorithms used for signal/data processing are not adequate for evolving threats that ballistic missile interceptor radar systems must detect. This research is to develop advanced algorithms that are compatible with the developed BMD Class X-Band Radar (XBR). These algorithms must provide an improvement in the ability to detect and track targets in a high clutter environment as well as in the presence of jammers and nuclear environments. Successful algorithms will be supportable by COTS processing systems and not require unique hardware solutions.

PHASE I: Develop and conduct proof-of-principle demonstrations of advanced signal/data processing algorithms using simulated radar data.

PHASE II: Update algorithms based on Phase I results and demonstrate those algorithms in a realistic environment using radar data. Demonstrate ability of algorithms to work in real-time in a high clutter environment.

PHASE III: Integrate algorithms into BMC4I systems and demonstrate the total capability of the updated system. Partnership with traditional DOD prime-contractors will be pursued since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: The signal/data processing algorithms have applicability to radio frequency systems that must operate reliably in a high noise environment. These algorithms would have applicability to the cell phone industry as well as commercial radar systems.

REFERENCES:
D.F. Elliot, editor, Handbook of Digital Signal Processing, Engineering Applications, Academic Press, Inc., San Diego, CA, 1987.

KEYWORDS: Signal Processing; Data Processing; Algorithm; XBR; Evolving Threat

MDA 03-039 TITLE: Multi-color VLWIR Focal Plane Array

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: MDA/GM

OBJECTIVE: Develop simultaneous/same-pixel Multi-color VLWIR (wavelength > 14 micrometers) Focal Plane Array technology for Exo-atmospheric Kill Vehicle.

DESCRIPTION: Current Exo-atmospheric Kill Vehicle seeker technology relies on multiple Long Wavelength Infrared (LWIR) Focal Plane Arrays (FPAs), filters, beam splitters, Read Out Integrated Circuits (ROICs) and cooling circuits to perform multi-color sensing to acquire, track, and discriminate objects. Problems with spatial co-registration of targets and sensor calibration, which result from this approach, complicate system design and reduce system reliability. A multi-color Very Long Wavelength Infrared (VLWIR) FPA with high pixel uniformity, reduced readout noise, improved resolution and operability would permit the EKV seeker to acquire, track, and discriminate colder objects at longer range than currently possible. A reduction in cost, volume, and mass is achieved by incorporating multiple-FPA features in a single full-resolution FPA. Detector material growth, high-speed signal processing, radiation hardening, ROIC performance at low temperature, manufacturability, operability, and thermal management issues must be addressed.

PHASE I: Conduct research and experimental efforts to demonstrate proof-of-principle of the proposed technology. Demonstrate the arguments that the developing technology will be reliable and affordable (Cost vs. payoff).

PHASE II: Demonstrate feasibility and engineering scale-up of proposed technology; identify and address technological hurdles; finalize phase I design and develop a prototype component. Demonstrate applicability to both selected military and commercial applications.

PHASE III: Many opportunities for the advancement of this technology during phase III program. Partnership with traditional DOD prime-contractors will be pursued since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Supporting instruments can be used in a wide variety of commercial environmental/remote sensing monitoring systems.

REFERENCES:
1. HgCdTe photodiodes for IR detection: a review; Reine, Marion B.; Proc. SPIE Vol. 4288, p. 266-277.
2. Dual-band infrared focal plane arrays; Rogalski, Antoni; Proc. SPIE Vol. 4340, p. 1-14.
3. Comparison of HgCdTe and QWIP dual-band focal plane arrays; Goldberg, Arnold C., et. al.; Proc. SPIE Vol. 4369, p. 532-546.

KEYWORDS: multicolor; multispectral; sensors; filters; VLWIR; FPA; IR detectors

MDA 03-040 TITLE: Thermal Management of GaN Based Power Amplifiers for X-Band Radars (XBR)

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: MDA/GM

OBJECTIVE: Design, develop, and demonstrate advances in Gallium Nitride (GaN) based power amplifier thermal packaging for GaN components intended for use in Ground-based Mid-course Defense (GMD) radars operating at 8-12 GHz (X-Band).

DESCRIPTION: Cooling high power GaN based heterostructure field effect transistor (HFET) power amplifiers is a critical problem in GaN based radars. Heat dissipation may ultimately limit the development and implementation of GaN based transmit/receive (T/R) modules. Thermal packaging employing new materials and configurations, bonding methods etc. is needed to overcome this potential limitation. A GaN based device substrate can be a design choice but SiC substrates are assumed for lattice miss-match and thermal conductivity considerations. The design should accommodate a minimum gate pitch and a maximum GaN power device density. These packages should be compatible with conventional multiple board modules and the method of heat removal from the overall T/R module should be specified.

PHASE I: Analyze, model, and design novel thermal packaging for GaN based power HFETs. Conduct proof-of-principle demonstrations that include documentation in the form of thermal images of the GaN devices, their packaging, and the surrounding circuit. The demonstration should include current state of the art GaN power HFETs and should maintain steady state temperature of the GaN HFET channels below 150 C.

PHASE II: Develop and demonstrate prototype thermal packaging that meets or exceeds heat dissipation requirements for GaN based T/R modules. Conduct hardware tests to evaluate the performance of the package design using multiple state of the art GaN based HFETs in a realistic environment. Total heat dissipation is expected to be on the order of 100 W. Thermal management materials should be designed to keep the transient and steady state channel temperature at or below 150 C. Prepare detailed plans to implement demonstrated capabilities on critical military and commercial applications.

PHASE III: Produce production quality packaging that meet or exceed requirements. GaN power HFETs are expected to reach and greatly exceed 30 W/mm.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: Dual applications exist for advanced packaging for GaN based power amplifiers throughout the DoD and commercial industries. Commercial radars, communications equipment, especially wireless, cell phone, and satellite, will have commercial potential for this development.

REFERENCES:

1. http://nsr.mij.mrs.org/
2. http://nina.ecse.rpi.edu/shur/Tutorial/GaNtutorial2/index.htm

KEYWORDS: Thermal management; thermal packaging; GaN based device packaging; GaN based HFETs; GaN Power Amplifiers; Radar; Transmit/Receive Module; X-band; GaN based materials processing

MDA 03-041 TITLE: Reliability, Reproducibility, and Stability of Gallium Nitride (GaN) Based Devices for X-and Radars (XBR)

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: MDA/GM

OBJECTIVE: Identify, explain, model, and demonstrate failure modes in current and proposed AlGaN/GaN heterostructure field effect transistor (HFET) architectures and identify and demonstrate solutions that will lead to high yield manufacture and production of superior, reliable, and stable devices operating at 8-12 GHZ under high power/temperature conditions. These devices are intended for use in Transmitter/Receiver (T/R) modules for Ground Based Mid-course Defense (GMD) radar systems.

DESCRIPTION: Long-term device stability and reproducibility of superior performance of Gallium Nitride (GaN) based transistor technology must be addressed. Quality of materials, strain distribution, lattice mismatch, potential distribution, edge effects, current crowding, and contact robustness contribute to device instability and degradation in device performance, especially at high-current operation. Device aging also leads to more pronounced current collapse, threshold voltage shift, increased gate and drain-to-source leakage, increased low frequency and microwave noise, and reduced reliability. Part of the purpose of this topic is to research and explain common failure mechanisms in HFETs resulting from essential features such as the dynamics of the AlGaN/GaN interface and different ohmic contact metalization schemes.

PHASE I: Analyze, model, and explain the physics of various failure mechanisms in GaN based HFETs. Design and conduct proof-of-principle demonstrations of solutions to these mechanisms.

PHASE II: Develop and demonstrate prototype GaN based HFETs that demonstrate viability, reproducibility, and stability of proposed solution(s) by conducting operational life tests on more than 20 devices under high power/temperature conditions for periods greater than 1000 hours under pulsed operating conditions where the channel temperature does not exceed 150 C. These HFETs should show no significant degradation in power, bandwidth, or efficiency. Prepare detailed manufacturing plans that ensure high yield producibility.

PHASE III: Produce production quality HFETs for use in power amplifiers that meet or exceed 30 W/mm per monolithic chip at 8-12 GHZ with power added efficiency of 25-30%.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: Commercial radars, communications equipment, cell phones, and satellites will benefit from this development.

REFERENCES:

1. http://nsr.mij.mrs.org/
2. http://nina.ecse.rpi.edu/shur/Tutorial/GaNtutorial2/index.htm

KEYWORDS: GaN based HFETs; GaN Power Amplifiers; Radar; Transmit/Receive Module; X-band; GaN based materials processing

MDA 03-042 TITLE: Data Fusion for Improved Acquisition, Tracking and Discrimination

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: MDA/GM

OBJECTIVE: Develop algorithms, software, and/or hardware necessary to collect, process, and fuse information from multiple sensors based on multiple platforms (XBR, SBIRS, EKV, UEWR) in real time in order to improve acquisition, tracking and discrimination of threat objects in a cluttered environment.

DESCRIPTION: Timely fusion of data collected from a variety of active and/or passive sensors that acquire information from multiple perspectives, may provide a more accurate picture of the adversary threat cloud than any one sensor or group of sensors operating independently. Algorithms, software, and/or hardware that enable this synergistic fusion and interpretation of data from disparate GMD sensors should enhance system acquisition, tracking and discrimination of threat objects in a cluttered environment. Fusion of data at several levels may be required since the Exo-atmospheric Kill Vehicle alone contains multiple sensors. Technical issues that must be addressed include: spatial and temporal registration of sensors, data throughput within and between sensor platforms, processing speed and capacity, and sensor calibration.

PHASE I: Develop and conduct proof-of-principle demonstrations of advanced data fusion concepts using simulated sensor data.

PHASE II: Update/develop technology (algorithms, software, hardware, or a combination thereof) based on Phase I results and demonstrate technology in a realistic environment using data from multiple sensors. Demonstrate ability of technology to work in real-time in a high clutter environment.

PHASE III: Integrate technology into GMD system and demonstrate the total capability of the updated system. Partnership with traditional DOD prime-contractors will be pursued since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: The technology is applicable to robotic systems, earth sciences, weather science, biometrics, transportation systems, and industrial applications requiring process monitoring by multiple-sensors.

REFERENCES:
1. McDaniel, R., et. al., "Image Fusion for Tactical Applications," Proc. SPIE 3436 pp. 685-695, (1998).
2. Smith, P. W. and Elstrom, M. D., "Stereo-Based Registration of Multi-Sensor Imagery for Data Fusion and Visualization," Opt. Eng. (40) 3, pp. 352-361, (2001).
3. Schwering, P. B. W., "Sensor Fusion of GPR, MT, and TIR," Research on Demining Technologies Joint Workshop, 12-14 July 2000.
4. McGuirk, P., Donohoe, G., Lyke, J., "Malleable Signal Processor: A General Purpose Module for Sensor Integration," 2000 Military and Aerospace Applications of Programmable Devices and Technologies Conference.

KEYWORDS: Sensor Fusion; Data Fusion; Sensor Integration; Signal Processing; Algorithm; Multi-Sensor

MDA 03-043 TITLE: Advanced Real Time Discrimination Architecture

TECHNOLOGY AREAS: Information Systems, Weapons

ACQUISITION PROGRAM: MDA/GM

OBJECTIVE: Improve real time database architecture in support of missile defense system target discrimination.

DESCRIPTION: Aggregate disparate sources of target-complex and associated data into a metalanguage (for example, Extensible Markup Language) database, and develop prototype architecture to syndicate the information to end users, all in real time. The GMD requires the capability to aggregate, fuse, integrate, correlate, syndicate, and otherwise manipulate data associated with the discrimination process from a diverse array of sensors and environment monitors in real time for some number of target complexes. The sources of this data use various formats that will require translation during the aggregation process. The data is generated by various sources with disparate, often incompatible, characteristics such as quality ratings and object specifications (radar, IR, visible). For example, the metalanguage elements may include and integrate radar returns and optical measurements. The metalanguage-formatted real time distributed database architecture must be designed to enable a broad range of heterogeneous discrimination applications that support Battle Management systems such as commander displays, and automated processes such as weapon systems. The solution should leverage Internet-based technologies and open standards.

PHASE I: Conduct research and experimental efforts to demonstrate proof-of-principle of the proposed technology. Measure and report performance improvements over current state-of-the-art. Use contractor-generated notional data.

PHASE II: Demonstrate readiness of technology. Fabricate and test prototype hardware/software. Demonstrate applicability to both selected military and commercial applications.

PHASE III: Insert this technology into future GMD BMC3 systems. Adapt this technology to commercial markets.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technology may have commercial and industrial application in remote operations and airline communications.

KEYWORDS: information aggregation; syndication; discrimination; sensors; fusion; correlation; missile defense; BMC3.

MDA 03-044 TITLE: Physics Based Discrimination Algorithms

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: MDA/GM

OBJECTIVE: Develop physics based discrimination algorithms to improve GMD's ability to identify target objects in cluttered environments.

DESCRIPTION: Current and anticipated sensors available to GMD for discrimination of threat objects include Radar, LADAR, and passive detectors operating in the infrared and visible bands. These sensors may operate from a variety of platforms in space, in the atmosphere, and on the earth's surface. The Exo-atmospheric Kill Vehicle may have both passive and active sensors onboard. The goal of this effort is to develop innovative algorithms that can utilize available sensor inputs in conjunction with the basic laws of physics to discriminate threat objects from decoys set against a variety of natural backgrounds populated with countermeasures. Algorithms supporting discrimination approaches based on the use of plausible alternate active or passive sensors may also be considered.

PHASE I: Develop and conduct proof-of-principle demonstrations of advanced discrimination algorithms using simulated sensor data.

PHASE II: Update algorithms based on Phase I results and demonstrate those algorithms in a realistic environment using actual sensor data. Demonstrate ability of algorithms to work in real-time in a stressing environment.

PHASE III: Integrate algorithms into GMD systems and demonstrate the total capability of the updated system. Partnership with traditional DOD prime-contractors will be pursued since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: Physics based discrimination algorithms have applicability in robotics, earth science, transportation, law enforcement, medicine and industrial production.

REFERENCES:
1. Acetta, J.S. and Schumaker, D. L., Ed., The Infrared and Electro-Optical Systems Handbook, Vol. 1-8, SPIE Press, 1993.
2. Knott, E. F., et. al., Radar Cross Section, 2nd Ed., Artech, MA, 1993.
3. Jelalian, A.V., Laser Radar Systems, Artech, MA, 1992.
4. http://www.nist.org/

KEYWORDS: Algorithm; Target Discrimination; Evolving Threat; IR Signature; Radar Cross Section; Counter-Counter Measure.

MDA 03-045 TITLE: Advanced Signal Processing

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: MDA/GM

OBJECTIVE: Develop advanced signal processing technologies, to include: algorithms, software, and/or hardware, which contribute to enhanced target acquisition, tracking, and discrimination.

DESCRIPTION: This research is aimed at developing advanced signal processing capabilities that will optimize sensor functionality for any or all sensor platforms contributing to GMD (XBR, SBIRS, UEWR, EKV seeker). These signal processing innovations must improve detection, tracking and discrimination of targets in high clutter environments that may also include: jammers, nuclear effects, flash effects or cool backgrounds. Innovations that increase the probability of detecting targets that have a smaller radar/LADAR cross section or a cooler thermal signature are also desired.

PHASE I: Develop and conduct proof-of-principle demonstrations of advanced signal processing algorithms using simulated sensor data.

PHASE II: Update algorithms based on Phase I results and demonstrate those algorithms in a realistic environment using sensor data. Demonstrate ability of algorithms to work in real-time in a high clutter environment.

PHASE III: Integrate algorithms into GMD systems and demonstrate the total capability of the updated system. Partnership with traditional DOD prime-contractors will be pursued since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: Signal processing algorithms have applicability in communications, commercial radar and space science.

REFERENCES: D.F. Elliot, editor, Handbook of Digital Signal Processing, Engineering Applications, Academic Press, Inc., San Diego, CA, 1987.

KEYWORDS: Signal Processing; Data Processing; Optical Signal Processing; Algorithm; Evolving Threat.

MDA 03-046 TITLE: Advanced Engagement Planning

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: MDA/GM

OBJECTIVE: Develop methods for increasing the performance of an existing engagement planning system.

DESCRIPTION: Higher performance engagement planning capabilities would improve GMD's ability to handle increased threat numbers and expanded weapons capabilities in less time. Seek to develop scalable techniques compatible with the Battle Management Command and Control (BMC2) infrastructure that will be in a form ready for integration with the system. Accommodate increased threat numbers and capabilities such as dog-leg maneuvers and delayed interceptors. Increase the state space for planning. Directly impacts timelines due to critical sections of planning algorithms that cannot be run in parallel.

PHASE I: Develop concept for improving GMD engagement planning capabilities. This should include the development of a prototypical engagement planning capability with nominal sensors, missile and threat parameters, a concept for improving the performance, metrics for capturing the amount of performance improvement, and a methodology to "prove" the improvement concept(s) will work. Perform technical, sensitivity and feasibility analysis to estimate the amount of performance improvement resulting from the development of the proposed performance improvement concept(s).

PHASE II: Demonstrate proposed performance improvement technology against the metrics established in Phase I. Assess impact of technology on engagement planning accuracy, reliability, and maintainability. Determine growth (expansibility and scalabilty) and adaptability of demonstrated concept.

PHASE III: This technology can be applied across a variety of military weapons engagement planning systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Enhance performance of Air Traffic Control Systems, Communications/Network Management Systems, modeling and simulation, automated logistics and transportation systems, medical research, etc.

REFERENCES:

1. BMDO FACT SHEET 122-00-11: Battle Management, Command, Control and Communications, November 2000, http://www.acq.osd.mil/bmdo/bmdolink/pdf/jn0024.pdf
2. Gompert, David C. and Jeffrey A. Isaacson, Planning a Ballistic Defense System of Systems – An Adaptive Strategy, IP-181 (1999) RAND Issue Papers,
http://www.rand.org/publications/IP/IP181/
3. Seffers, Georg I., Army Fine-Tunes Missile Defense C3, Federal Computer Week, August 25, 2000, http://www.fcw.com/fcw/articles/2000/0821/web-army-08-25-00.asp
4. DOD Joint Technical Architecture (JTA), Version 3.1, http://www-jta.itsi.disa.mil, March 2000
5. Defense Information Infrastructure Common Operating Environment, http://diicoe.disa.mil/coe/

KEYWORDS: Command and Control; Engagement Planning; Intelligent Agents; Adaptive Algorithms; High Performance Computing; Real-time processing

MDA 03-047 TITLE: Management of Distributed Real-time Databases

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: MDA/GM

OBJECTIVE: Develop technology to support the management of advanced real-time distributed databases required to enable an optimal environment for tight coupling, low latency, and real-time database solutions for Ground-based Midcourse Defense applications.

DESCRIPTION: The ability to integrate and manage vast amounts of data from distributed, heterogeneous sources is critical for decision makers in Battle Management Command and Control (BMC2) systems. New methodology, software, and hardware tools and techniques are needed to intelligently and automatically assist the warfighter in transforming this data into useful and operational knowledge. Technology should improve situational awareness, forecasting, planning and resource allocation, and reduce reaction/decision times. Core functionality should include: fusion of data from heterogeneous sources; robust handling of missing or imprecise data; filtering of irrelevant information; event detection and situation assessment based on fused data; mapping of data and knowledge to appropriate human effector and interface type; and response recommendations presented in a situationally-relevant manner.

PHASE I: Conduct experimental efforts to demonstrate proof-of-principle of the proposed technology to manage real-time distributed databases. Demonstrate the initial feasibility of integrating the technology into an existing system.

PHASE II: Demonstrate feasibility and engineering scale-up of proposed technology; identify and address technological hurdles. Demonstrate applicability to both selected military and commercial applications.

PHASE III: Integrate technology into BMC2 systems and demonstrate the total capability of the updated system.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Technology that supports the management of real-time distributed databases has significant commercial potential. Specific private sector areas include the electronic commerce and almost any web-based data rich applications.

REFERENCES:
1. J.S. Przemieniecki, Critical Technologies for National Defense, AIAA Education Series, Washington, D.C., 1991.
2. M.Tamer Ozsu, Patrick Valduriez, Principles of Distributed Database Management, Prentice Hall, New York, 1999.

KEYWORDS: databases; data management; distributed data; heterogeneous data sources; data; information technology; data processing

MDA 03-048 TITLE: Define/Demonstrate Beryllium (Be) Substitute Material

TECHNOLOGY AREAS: Sensors, Electronics, Weapons

ACQUISITION PROGRAM: MDA/GM

OBJECTIVE: Investigate/define suitable Be/Be alloy substitute that is affordable, meets Be/Be alloy material profile/characteristics, is producible in a production environment, and does not pose any of the health hazards associated with Be/Be alloy materials.

DESCRIPTION: As an industrial material, Be/Be alloy possesses some uncommon qualities such as its ability to withstand extreme heat, remain stable over a wide range of temperatures and function as an exceptional thermal conductor. These characteristics have made it a unique material suitable for a host of diverse, demanding applications. Be/Be alloy structures, including sensor mirrors, are used in a wide range of military/defense applications. It has been the material of choice for many applications due to its desirable characteristics/properties despite health hazard concerns associated with material handling and per unit cost. The health hazard concerns are becoming increasingly more visible and it is anticipated that Be/Be alloy structures will become unavailable within the next seven years. The challenge is to find a material that fulfills all of the desirable, or least the most critical, Be/Be alloy properties/characteristics without any of the associated health hazard concerns in an affordable, producible material to fill the void when Be/Be alloy is no longer an option.

Phase I: Investigate suitable Be/Be alloy substitute materials. Develop a matrix to do a comparison/cross walk of desirable properties, cost per unit, producibility characteristics and availability. Primary desirable characteristics include but are not limited to: light weight (Be is one of the lightest of all metals), high melting point, rigidity (stiffness), dimensional stability over a wide range of temperatures, hardness, high tensile strength, resistance to corrosion from acids, fatigue resistance, nonmagnetic properties, and electrical and thermal conductivity.

Phase II: With the successful completion of Phase I, down select one to three candidate materials and prototype production representative structure(s) for qualification-type testing. The prototype structures will be selected based on the most desirable Be/Be alloy characteristics that can be demonstrated in testing scenarios. Input from prime contractors will be solicited to assist in determination of most desirable property characteristics to demonstrate. However, at this juncture it appears that rigidity, lightweight, high tensile strength, dimensional stability over a wide range of temperature and fatigue resistance are the more desirable characteristics to be tested. Once the test parameters are selected, a test plan will be developed to demonstrate the desired properties. The prototype structure, possibly to scale, will be fabricated and the testing will occur. Test results will be documented so that performance can be compared to Be/Be alloy structure performance. These results will be available to interested commercialization partners.

Phase III: Successful completion of Phase II will result in a demonstrated/validated production representative prototype component that can serve as the basis of the migration to more acceptable (from the health hazard perspective) material solution for candidate weapon system. It is anticipated that the cognizant prime contractor will welcome the opportunity to partner with the proven substitute material provider.

PRIVATE SECTOR COMMERICAL POTENTIAL: The use of beryllium, as an alloy, metal and oxide, in electronic and electrical components, and in aerospace and defense applications accounted for an estimated 80% of the total 2000 US consumption. Beryllium and beryllium alloys are used as base metal in battery contacts and electronic connectors in cell phones and base stations. Beryllium-Copper alloys are often the only material that meets the need for high reliability and miniaturization in these applications as well as being used as castings in the aerospace industry. FM radio, high-definition and cable television and underwater fiber optic cable systems also depend on beryllium. Beryllium metal is used principally in aerospace and defense applications, such as surveillance satellite and space vehicle structures, inertial guidance systems, military aircraft brakes and space optical system components. Military electronic targeting and infrared countermeasure systems use beryllium components, as do radar navigation systems. Beryllium is also a staple material in Apache helicopters, fighter aircraft and tanks, and aircraft landing gear components. In the US space shuttles, several structural parts and brake components use metallic beryllium. Beryllium oxide is an excellent heat conductor and acts as an electrical insulator in some applications. However, beryllium oxide serves mainly as a substrate for high-density electronic circuits for high-speed computers, and automotive ignition systems. The medical profession relies on beryllium for applications in pacemakers and lasers to analyze blood for HIV and other diseases and for X-ray windows since it is transparent to X-rays. The uses for Be/Be alloys spans an enormous range of commercial as well as defense applications and the commercial potential for a substitute material is virtually incalculable.

References: None

KEYWORDS: Beryllium; stiffness; hardness; strong; stable; fatigue-resistance;

MDA 03-049 TITLE: Innovative Manufacturing Processes

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Materials/Processes, Battlespace, Space Platforms, Weapons

ACQUISITION PROGRAM: MDA/MP

Objective: Develop innovative processes that improve manufacturing capabilities, product quality and reliability, reduce unit costs and enhance manufacturing yields and sub-systems and component performance.

Description: MDA is seeking innovative approaches that will allow economically feasible acquisition of new process technologies for components of the ballistic missile defense system. This can range from improvements in fabrication of advanced materials through innovative application of methods and tools to improve manufacturing processes and procedures on current systems and subsystems. MDA is also interested in process technology that facilitates the transition of a product (breadboard, brass board or prototype) from an R&D environment to any manufacturing environment (commercial, defense or both).

Technical areas of interest include, but are not limited to:

· Passive Electro-Optic Sensors and Active Ladar: Infra-red (SWIR, MWIR, LWIR and VLWIR); dual-band and multi band systems; angle-angle range direct detection and coherent ladars and components (transmitters/receivers).

· Radars and RF Components: Advanced GaAs and wideband gap (WBG) high power amplifiers, (UHF through Ka Band); solid state transmitters (IMPATT diodes), thermal management systems, software defined waveform generators/receivers; Advanced Multi-Frequency Generators (AMFG); photonics; MMIC packaging and high-density interconnects; Multi-band frequency date links, multi-band antennas.

· Signal Processing, Data Fusion and Imaging: Advanced Optical Processor (AOP), flow motion sensor, wide instantaneous bandwidth processing of multiple waveforms (Pseudo-Random Noise (PRN) codes, chaotic waveforms).

· Radiation Hardened Electronics: FPA Readouts, FPGAs, ASICs, microprocessors, memory, analogue and digital devices.

· Propulsions: Boosters, divert and attitude control, nozzles, components, high temperature materials.

· Composite Materials and Structures: Polymer matrix and metal matrix graphite and ceramic composites for structures and thermal management systems, missile canisters. integrated thermal /structured aeroshells.

· Batteries: Advanced thermal batteries, lithium and lithium oxyhalide batteries.

Phase I: Demonstrate that a new or innovative process technology can meet MDA needs including, where appropriate, a process technology roadmap for implementing promising approaches for near term insertion into BMD element systems, subsystems, or components.

Phase II: Validate the feasibility of the process technology by demonstrating its use in the fabrication of prototype items for BMD element systems, subsystems, or components. A partnership with the current or potential supplier of BMD element systems, subsystems, or components is highly desirable. Identify any commercial benefit or application opportunities of the innovation.

Phase III: Successful demonstration of a new process technology and near-term application to one or more BMD element systems, subsystems, or components. This demonstration should also verify the potential for enhancement of quality, reliability, performance and reduction of unit cost or total ownership cost of the proposed subject.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Proposals should show how the innovation can benefit commercial business or should show that the innovation has benefits to both commercial and defense manufacturing methods. The projected benefits of the innovation to commercial applications should be clear, whether they reduce cost, improve producibility, or performance of products that utilize the innovation process technology.

References: BMDS Cost Drivers
http://www.winbmdo.com -BMDO/MP presentation at 2001 Defense Manufacturing Conference

KEYWORDS: reliability, reduced costs, yields, performance

MDA 03-050 TITLE: Innovative Operating Software

TECHNOLOGY AREAS: Air Platform, Information Systems, Ground/Sea Vehicles, Sensors, Electronics, Battlespace, Space Platforms, Weapons

ACQUISITION PROGRAM: MDA/MP

Objective: MDA is seeking innovative approaches to software that improves product capabilities, improves product quality and reliability, and reduces the time and cost of transitioning prototypes into production. Of special interest is the application of commercial software approaches, methods, and tools to mitigate problems encountered with legacy software, architectures, and languages, (e.g., ADA).

Description: MDA is seeking innovative approaches that will allow economically feasible acquisition of new software products and adaptation of software to changing situations (e.g., evolving threat). Many missile defense systems use proprietary software in an R&D/laboratory environment, and are subject to expensive, time-consuming custom integration into systems. Also, many legacy DoD systems upgraded for use by MDA employ antiquated software that is difficult to modify and maintain.

Specific technology areas include, but not limited to:

· Fault Tolerant Software: Development of techniques including modification of existing fault tolerant software with application to MDA systems.

· Object-Oriented Software Developments: MDA is interested in conversion of legacy codes into structures that facilitates software upgrades and improves life cycle costs.

· Software Libraries: Many algorithms and software models used for radar, electro-optic imaging, or other MDA applications could be standardized for use across multiple MDA systems.

Phase I: Develop conceptual software, firmware and hardware designs or modifications to existing software that address problem areas addressed above. Conceptual designs would include, but not be limited to, flowcharts, simulations and emulations, timing analyses, GUI designs (where applicable) and narrative descriptions of software operation.

Phase II: Validate the feasibility of the software by demonstrating its use in the testing and integration of prototype items for BMD element systems, subsystems, or components. Validation would include, but not be limited to, software based system simulations, operation in test-beds, or operation in a demonstration sub-system. A partnership with the current or potential supplier of BMD element systems, subsystems or components is highly desirable. Identify any commercial benefit or application opportunities of the innovation.

Phase III. Successful demonstration of new open/modular, non-proprietary, operating software. Demonstration would include, but not be limited to, demonstration in a real system or operation in a system level test-bed. This demonstration should show near term application to one or more BMD element systems, subsystems, or components.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Most innovations in operational software are taking place in the commercial sector. DoD & MDA need infusions of commercially strategic/design tools/middle-ware and software architectures. The projected benefits of the innovation to commercial applications should be clear, whether they reduce cost, improve producibility, or performance or products that utilize the innovation process technology.

References: http://www.winbmdo.com BMDO/MP presentation at 2001 Defense Manufacturing Conference
BMDS Cost Drivers

KEYWORDS: software, quality, reliability

MDA 03-051 TITLE: Ballistic Missile Innovative Electro-Optic Products

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Sensors, Electronics, Battlespace, Space Platforms, Weapons

ACQUISITION PROGRAM: MDA/MP

Objective: MDA is seeking innovative products that improve multi-spectral imaging and optical sensor capability, reliability and producibility in Ballistic Missile Defense systems. Innovations include, but are not limited to, application or or modification to existing products whether Commercial-off-the-shelf (COTS) or Military-off-the-shelf (MOTS) that are applied in creative ways to MDA systems, subsystems, or component requirements.

Description: Many missile defense products are fabricated in an R&D or laboratory environment and are subjected to expensive, time-consuming custom integration into systems. MDA is seeking innovative approaches that will allow economically feasible acquisition of new process technologies for components of the ballistic missile defense system. This can range from improvements in fabrication of advanced materials through innovative application of methods and tools to improve manufacturing processes and procedures on current systems and subsystems. MDA is also interested in process technology that facilitates the transition of a product (breadboard, brass board or prototype) from an R&D environment to any manufacturing environment (commercial, defense or both).

Technical areas of interest include, but are not limited to:

· Infra-red Focal Plane Arrays (SWIR, MWIR, LWIR and VLWIR) such as pixel density, sensitivity and manufacturing yields that enhance performance or lower production costs.

· Dual-band and multi band systems, subsystems and components such as pixel density, sensitivity, spectrum coverage and manufacturing yields that enhance performance or lower production costs.

· Laser Radar: Angle-angle range direct detection and coherent ladar systems, subsystems and components (transmitters/receivers) such as laser amplifier, oscillators, pump diode, Intensified Photo Diode (IPD) and Photo Multiplier Tube (PMT) arrays or other component design and manufacturing improvements that enhance performance or lower production costs.

Phase I: Develop conceptual framework for Electro-Optic product design or modification that will improve performance, lower cost, or increase reliability of BMD element systems, subsystems, or components.

Phase II: Validate the feasibility of the Electro-Optic product technology by demonstrating its use in the operation of prototype items for BMD element systems, subsystems, or components. A partnership with the current or potential supplier of BMD element systems, subsystems, or components is highly desirable. Identify any commercial benefit or application opportunities of the innovation.

Phase III: Successful demonstration of the Electro-Optic product technology. This demonstration should show near-term application to one or more BMD element systems, subsystems, or components. This demonstration should also verify the potential for enhancement of quality, reliability, performance and reduction of unit cost or total ownership cost of the proposed Electro-Optic product.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Proposals should show how the innovation can benefit commercial business or should show that the innovation has benefits to both commercial and defense manufacturing methods. The projected benefits of the innovation to commercial applications should be clear, whether they reduce cost, improve producibility, or performance of products that utilize the innovation process technology.

References: http://www.winbmdo.com -BMDO/MP presentation at 2001 Defense Manufacturing Conference BMDS Cost Drivers

MDA 03-052 TITLE: Ballistic Missile Innovative Radar and RF Products

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Sensors, Electronics, Space Platforms, Weapons

ACQUISITION PROGRAM: MDA/MP

Objective: MDA is seeking innovative products that improve Radars and RF system capability, reliability and producibility in Ballistic Missile Defense systems. Innovations include, but are not limited to, application or modification to existing products whether Commercial-off-the-shelf (COTS) or Military–off–the–shelf (MOTS) that are applied in creative ways to MDA systems, subsystems, or component requirements.

Description: Many missile defense products are fabricated in an R&D or laboratory environment and are subjected to expensive, time-consuming custom integration into systems. MDA is seeking innovative approaches that will allow economically feasible acquisition of new process technologies for components of the ballistic missile defense system. This can range from improvements in fabrication of advanced materials through innovative application of methods and tools to improve manufacturing processes and procedures on current systems and subsystems. MDA is also interested in process technology that facilitates the transition of a product (breadboard, brass board or prototype) from an R&D environment to any manufacturing environment (commercial, defense or both).

Technical areas of interest include, but are not limited to:

· Advanced Galium Arside (GaAs) and Wideband gap (WBG) High Power Amplifiers (HPA) in the frequency range from UHF through Ka Band such as enhancements to wafer manufacturing, device characterization and performance improvements, and amplifier module manufacturability, miniaturization, reliability that enhance performance or lower production costs.

· Solid State Transmitters such as IMPATT diode and transistor based design, manufacturability, reliability improvements that enhance performance or lower production costs.

· Thermal Management systems such as improvements in subsystem active and passive cooling, heat conduction and related manufacturability improvements that enhance performance or lower production costs.

· Software defined waveform generators and receivers such as programmable telemetry transceivers, associated software reliability and manufacturability that enhance performance or lower production costs.

· MMIC packaging and High–Density Interconnects (HDI) such as three-dimensional high–density interconnect, flip–chip, and high frequency/high power density packaging designs and manufacturability improvements.

· Multi–band frequency agile data links such as reprogramable multiband radio frequency data links which provides interoperability between multiple platforms with little or no modifications and least possible cost by permitting adaptation to the specific data link requirements through software loading.

· Multi–band Antennas such as phased array antenna structure, adaptive beamforming, and wideband T/R modules design and manufacturing improvements.

Phase I: Develop conceptual framework for Radar or RF system product design or modification that will improve performance, lower cost, or increase reliability of BMD element systems, subsystems, or components.

Phase II: Validate the feasibility of the Radar or RF system product technology by demonstrating its use in the operation of prototype items for BMD element systems, subsystems, or components. A partnership with the current or potential supplier of BMD element systems, subsystems, or components is highly desirable. Identify any commercial benefit or application opportunities of the innovation.

Phase III: Successful demonstration of the Radar or RF system product technology. This demonstration should show near-term application to one or more BMD element systems, subsystems, or components. This demonstration should also verify the potential for enhancement of quality, reliability, performance and reduction of unit cost or total ownership cost of the proposed Radar or RF system product.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Proposals should show how the innovation can benefit commercial business or should show that the innovation has benefits to both commercial and defense manufacturing methods. The projected benefits of the innovation to commercial applications should be clear, whether they reduce cost, improve producibility, or performance of products that utilize the innovation process technology.

References: http://www.winbmdo.com -BMDO/MP presentation at 2001 Defense Manufacturing Conference BMDS Cost Drivers

MDA 03-053 TITLE: Ballistic Missile Innovative Signal Processing, Data Fusion and Imaging Products

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Sensors, Electronics, Space Platforms, Weapons

ACQUISITION PROGRAM: MDA/MP

Objective: MDA is seeking innovative products that improve Signal Processing, Data Fusion and Imaging system capability, reliability and producibility in Ballistic Missile Defense systems. Innovations include, but are not limited to, application or modification to existing products whether Commercial-off-the-shelf (COTS) or Military–off–the–shelf (MOTS) that are applied in creative ways to MDA systems, subsystems, or component requirements.

Description: Many missile defense products are fabricated in an R&D or laboratory environment and are subjected to expensive, time-consuming custom integration into systems. MDA is seeking innovative approaches that will allow economically feasible acquisition of new process technologies for components of the ballistic missile defense system. This can range from improvements in fabrication of advanced materials through innovative application of methods and tools to improve manufacturing processes and procedures on current systems and subsystems. MDA is also interested in process technology that facilitates the transition of a product (breadboard, brass board or prototype) from an R&D environment to any manufacturing environment (commercial, defense or both).

Technical areas of interest include, but are not limited to:

· Advanced Optical Processors such as fourier optic, optical system and component, sensor array, A/D converter, processor and algorithm designs and manufacturability improvements or miniaturization that enhance performance or lower production costs.

· Flow Motion Sensors such as high integration single of multichip system, algorithm or sensor array designs and manufacturability improvements that enhance performance or lower production costs.

· Wide instantaneous bandwidth processing of multiple waveforms such as Pseudorandom noise (PRN) code, chaotic waveform and ultra-wideband modulation format designs or implementations that enhance performance or lower production costs.

Phase I: Develop conceptual framework for Signal Processing, Data Fusion and Imaging system product design or modification that will improve performance, lower cost, or increase reliability of BMD element systems, subsystems, or components.

Phase II: Validate the feasibility of the Signal Processing, Data Fusion and Imaging system product technology by demonstrating its use in the operation of prototype items for BMD element systems, subsystems, or components. A partnership with the current or potential supplier of BMD element systems, subsystems, or components is highly desirable. Identify any commercial benefit or application opportunities of the innovation.

Phase III: Successful demonstration of the Signal Processing, Data Fusion and Imaging system product technology. This demonstration should show near-term application to one or more BMD element systems, subsystems, or components. This demonstration should also verify the potential for enhancement of quality, reliability, performance and reduction of unit cost or total ownership cost of the proposed Signal Processing, Data Fusion and Imaging system product.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Proposals should show how the innovation can benefit commercial business or should show that the innovation has benefits to both commercial and defense manufacturing methods. The projected benefits of the innovation to commercial applications should be clear, whether they reduce cost, improve producibility, or performance of products that utilize the innovation process technology.

References: http://www.winbmdo.com -BMDO/MP presentation at 2001 Defense Manufacturing Conference BMDS Cost Drivers

MDA 03-054 TITLE: Ballistic Missile System Composite Materials and Structures

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Sensors, Electronics, Battlespace, Space Platforms, Weapons

ACQUISITION PROGRAM: MDA/MP

OBJECTIVE: MDA is seeking innovative products that improve capability, reliability, and producibility in ballistic missile defense systems, including application of or modification of existing products, whether commercial off-the-shelf (COTS) or military off-the-shelf (MOTS), but applied in a creative way to unique MDA systems, sub systems, or component requirements.

DESCRIPTION: Many missile defense products are fabricated in an R&D/laboratory environment and are subject to expensive, time-consuming custom integration into systems. Product technology is transitioned from laboratory to factory without complete understanding of producibility constraints on product designs. Therefore, MDA is interested in innovative product improvements and innovative product applications of constantly evolving products technologies, within a path toward integration into MDA systems. This can range from improvements in fabrication of advanced materials to innovative products that improve the capability of current systems and subsystems. This may involve basic industrial research and development, characterization testing of advanced materials, development of improved material manufacturing and component assembly processes, ect., that lead to a specific product application. The goal is to enhance producibility of missile defense composite material and structure products, reduce cost, or improve product reliability and performance.

Technical areas of interest include, but are not limited to:

. Polymer matrix and metal matrix graphite and ceramic composites for structures and thermal management systems capitalizing on more recent rapid prototyping composite manufacturing techniques to reduce cost, weight, and lead time for MDA subsystems

· Interceptor Structures: Electronic enclosure assemblies, EKV EU Compression Clips and Rings, EU Heatsink, EKV EU Housing and Covers, EKV Hardened Sunshade, and Sensor Platform Mirrors and Support Structures, THAAD DACS ACS Manifold, Aerodynamic fins.

· RF antenna structures: Use of lightweight composite materials and advance thermal management approaches for both Ground Based Mid-Course and Terminal Defense layers.

· Missile Canisters: Use of more recent manufacturing improvements in commercial industry to reduce cost and lead-time on large structures such as Missile Canisters.

· Integrated thermal/structural aeroshells/shrouds: Replace the current airframe manufacturing process and designing a one-step infusion process for stitched glass knitted bundle pre-forms for application to low cost, lightweight, and high performance aeroshells and shrouds.

Phase I: Develop conceptual framework for composite material and structure product design or design modification, which would be used for MDA integration into a system or subsystem to increase performance, lower cost, or increase reliability.

Phase II: Validate the feasibility of the composite material and structure product technology by demonstrating its use in the operation of prototype items for BMD elements systems, or components. A partnership with the current or potential supplier of BMC element systems, subsystems, or components in highly desirable. Identify any commercial application of technology or opportunities of benefit from using the innovation.

Phase III: Successful demonstration of the Composite Materials technology. This demonstration should show near-term application to one or more BMD element systems, subsystems, or components. This demonstration should also verify the potential for enhancement of quality, reliability, performance and reduction of unit cost or total ownership cost of the proposed subject.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Most innovations in manufacturing processes take place at the supplier/subcontractor level. The proposals should show how the innovation can benefit commercial business or should show that the innovation has benefits to both commercial and defense manufacturing methods. The projected benefits of the innovation to commercial applications should be clear, whether they reduce cost, or improve producibility or performance of products that utilize innovation process technology.

REFERENCES: http://www.winbmdo.com BMDO/MP presentation at 2001 Defense Manufacturing Conference.

MDA 03-055 TITLE: Ballistic Missile System Innovative Propulsion Products

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Materials/Processes, Sensors, Electronics, Battlespace, Space Platforms, Weapons

ACQUISITION PROGRAM: MDA/MP

Objective: MDA is seeking innovative products that improve propulsion capability, reliability and producibility in ballistic missile defense systems, including application of, or modification of existing products, whether commercial off-the-shelf (COTS) or military off-the-shelf (MOTS), but applied in a creative way to unique MDA system, subsystem or component requirements.

Description: Many missile defense products are fabricated in an R&D/laboratory environment and are subject to expensive, time-consuming custom integration into systems. Product technology is transitioned from laboratory to factory without complete understanding of producibility constraints on product designs. Propulsion systems and components require lengthy development and testing cycles and there is much technical, cost and schedule risk associated with changes. Therefore, MDA is interested in innovative product improvements and innovative application of constantly evolving product technologies, within a path toward integration into MDA systems. This can range from improvements in fabrication of advanced materials to innovative products that improve the capability of current propulsion systems and subsystems. This may involve basic industrial research and development, characterization testing of advanced materials, development of improved material manufacturing and component assembly processes, etc., that lead to a specific product application. The goal is to enhance producibility of missile defense propulsion products, reduce unit cost, or improved product reliability and performance.

Technical areas of interest include, but are not limited to:

· Booster technology, including innovative assembly processes, novel uses of materials for rocket motor propellants, rocket motor cases and insulators, enabling technologies for high burn rate propellants; reduction of drag and aero-heating; variable thrust and thrust management systems

· Divert and attitude control, including enabling technologies for liquid propellants, bi-propellants, and solid propellants; injectors, valves, seals and computerized controls; innovative cold gas technologies; hot gas generators

· Nozzles, and nozzle components, including innovative designs and applications of high temperature materials for throats and nozzles and thrust vector controllers (TVC); use of refractory metals; use of high temperature composites

· Innovative Assembly Processes, including basic industrial research involving innovative joining of materials; innovative molding of composite materials

Phase I: Develop conceptual framework for propulsion product design or design modification, which would be used for the propulsion product and MDA integration into a system or subsystem to increase performance, lower cost, or increase reliability.

Phase II: Validate the feasibility of the propulsion product technology by demonstrating its use in the operation of prototype items for BMD element systems, subsystems or components. A partnership with the current or potential supplier of BMC element systems, subsystems, or components is highly desirable. Identify any commercial application of technology or opportunities of benefit from using the innovation.

Phase III: Successful demonstration of a new product technology. This demonstration should show near-term application to one or more BMD element systems, subsystems, or components. This demonstration should also verify the potential for enhancement of quality, reliability, performance and reduction of unit cost or total ownership cost of the proposed subject.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Most innovations in manufacturing processes take place at the supplier/subcontractor level. The proposals should show how the innovation can benefit commercial business or should show that the innovation has benefits to both commercial and defense manufacturing methods. The projected benefits of the innovation to commercial applications should be clear, whether they reduce cost, improve producibility, or performance of products that utilize the innovation process technology.

References: http://www.winbmdo.com BMDO/MP presentation at 2001 Defense Manufacturing Conference.

MDA 03-056 TITLE: Ballistic Missile System Innovative Radiation Hardened/Tolerant Electronics Products

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Sensors, Electronics, Battlespace, Space Platforms, Weapons

ACQUISITION PROGRAM: MDA/MP

OBJECTIVE: MDA is seeking innovative products that improve Radiation Hardness/Tolerance of Electronics for ballistic missile defense systems, including application of, or modification to existing products, whether commercial off-the-shelf (COTS) or military off-the-shelf (MOTS), but applied in a creative way to MDA systems, sub systems, or component requirements. The overall program goal is to expand on previous efforts in dual-use applications programs which attempted to exploit commercial CMOS foundry capability by tailoring design rules to enhance radiation hardness/tolerance at the device level and to leverage encapsulation techniques. The results will be the capability to manufacture affordable radiation hardened, or radiation tolerant electronic devices.

DESCRIPTION: Many missile defense products are fabricated in an R&D/laboratory environment and are subject to expensive, time-consuming custom integration into systems. Product technology is transitioned from laboratory to factory without complete understanding of producibility constraints on product designs. Therefore, MDA is interested in innovative product improvements and innovative product applications of constantly evolving products technologies with a path toward integration into MDA systems. This can range from improvements in fabrication of advanced materials to innovative products that improve the capability of current systems and subsystems. This may involve basic industrial research and development, characterization testing of advanced materials, development of improved material manufacturing and component assembly processes, etc., that lead to a specific product application. The goal is to enhance the radiation hardness, or radiation tolerance of missile defense products with a secondary goal to reduce unit cost, or improve product reliability and performance.

Technical areas of interest include, but are not limited to:

· Focal Plane Array (FPA) Readouts:

· Field Programmable Gate-Array (FPGA):

· Application-Specific Integrated Circuit (ASIC):

· Thin Film Silicon on Insulator (SOI):

· Microprocessors:

· NonVolatile Memory:

· Analog devices: (A to D Converters)

· Mixed Signal Processors: (Analog/Digital Hybrids)

Phase I: Develop conceptual framework for Radiation Hardened/Tolerant Electronics product design or design modification, which would be used for MDA integration into a system or subsystem to increase performance, lower cost, or increase reliability.

Phase II: Validate the feasibility of the Radiation Hardened/Tolerant Electronics product technology by demonstrating its use in the operation of prototype items for BMD elements systems, or components. A partnership with the current or potential supplier of BMD element systems, subsystems, or components is highly desirable. Identify any commercial application of technology or opportunities of benefit from using the innovation.

Phase III: Successful demonstration of the Radiation Hardened/Tolerant Electronics product technology. This demonstration should show near-term application to one or more BMD element systems, subsystems, or components. This demonstration should also verify the potential for enhancement of quality, reliability, performance and reduction of unit cost or total ownership cost of the proposed subject.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Most innovations in manufacturing processes take place at the supplier/subcontractor level. The proposals should show how the innovation can benefit commercial business or should show that the innovation has benefits to both commercial and defense manufacturing methods. The projected benefits of the innovation to commercial applications should be clear, whether they reduce cost, or improve producibility or performance of products that utilize innovation process technology.

REFERENCES: http://www.winbmdo.com BMDO/MP presentation at 2001 Defense Manufacturing Conference.

MDA 03-057 TITLE: Ballistic Missile System Innovative Batteries

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Materials/Processes, Sensors, Electronics, Battlespace, Space Platforms, Weapons

ACQUISITION PROGRAM: MDA/MP

Objective: MDA is seeking innovative products that improve capability, reliability and producibility in ballistic missile defense systems, including application of, or modification of existing products, whether commercial off-the-shelf (COTS) or military off-the-shelf (MOTS), but applied in a creative way to unique MDA system, subsystem or component requirements.

Description: Many missile defense battery products are fabricated in an R & D/ laboratory environment and are subject to expensive, time-consuming custom integration into systems. Product technology is transitioned from laboratory to factory without complete understanding of producibility constraints on product designs. Therefore, MDA is interested in innovative product improvements and innovative application of constantly evolving product technologies, within a path toward integration into MDA systems. This can range from improvements in fabrication of advanced materials to innovative products that improve the capability of current systems and subsystems. The goal is to enhance producibility of missile defense products, reduce unit cost, or improve product reliability and performance.

Technical Area of Interest Include, but are not limited to:

· Advanced thermal batteries: lithium ion, lithium oxyhalide, and lithium ion polymer.
For example: enhanced safety of high energy lithium rechargeable batteries, improved separators for Lithium Oxyhalide batteries, or thermal management of very high current pulse loads in batteries.

· Develop lower cost batteries by: reducing the cost of the anode, cathode, separator, and electrolyte materials by researching and developing alternative materials that have the same or better electrochemical properties at lower cost.

· Research and develop improved electrochemical processing techniques to lower costs and improve battery safety, size, weight, and improved electrolytes with higher transport numbers.

· Enabling technologies to produce extremely lightweight, safe, relatively inexpensive, inherently powerful primary batteries with enhanced producibility and manufacturability are necessary for mission success.

Phase I: Develop conceptual framework for battery design/design modification for MDA integration into system or subsystem to increase performance, lower cost and increase reliability and producibility.

Phase II: Validate the feasibility of the battery technology by demonstrating its use in the operation of prototype items for MDA element systems, subsystems or components. A partnership with the current or potential supplier of these systems is desirable. Identify and commercial application of technology or opportunities of benefit from using the innovation.

Phase III: Successful demonstration of a new enhanced product technology. This demonstration should clearly show near-time application to one or more MDA element systems, subsystems or components. This demonstration should also verify the potential for enhanced quality, performance, producibility and lower cost of the proposed new technology.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Most innovations in manufacturing processes take place at the supplier/subcontractor level. These proposals should show how the innovation can benefit commercial business or show that the innovation has benefits to both military and commercial manufacturing methods. The projected benefits to commercial applications should be clear, whether they reduce cost, improve producibility, or performance of products that utilize the innovative process technology.

MDA 03-058 TITLE: Increased Thrust to weight ratio for small Rocket Motors (Directed Attitude Control System)

TECHNOLOGY AREAS: Air Platform, Weapons

ACQUISITION PROGRAM: MDA/SE

OBJECTIVE: Increase the acceleration of missiles by utilization of engineering analysis and optimization to maximize the thrust force generated from the exothermic chemical reactions of its fuel and air mixture while devising schemes to reduce vehicle weight.

DESCRIPTION: Enable engineers and scientists to improve upon the acceleration of missiles by allowing them to devise engineering optimization techniques. These derived engineering techniques will take into account the fuel to air ratio and types of fuel, vehicle weight, thrust generated, etc. The reduction in weight of the small rocket motors will result in lower costs to go along with the improvement in performance of the missile system.

PHASE I: Devise a mathematical or analytical method for determining how to improve acceleration and increase specific impulse by increasing the current thrust to weight ratios for small rocket motors.

PHASE II: Develop and test the analytical approach for increasing the thrust to weight ratio to. The analysis refinement approach should consist of performing the analysis for a variety of scenarios that take into account fuel to air ratio and types of fuel, vehicle weight, thrust generated, etc.

PHASE III: Prepare the analytical approach/software package to be marketed for use in the government and private sector.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This developed optimization scheme along with the results could be utilized in the commercial aircraft industry to help improve fuel efficiency and reduce the cost of jet engines.

REFERENCES: None

KEYWORDS: Optimization, Analysis, Rocket Motors, Propulsion, Missiles, Model and Simulation, Acceleration, Specific Impulse

MDA 03-059 TITLE: Low Cost IR Windows for High Stress Environments

TECHNOLOGY AREAS: Sensors, Weapons

ACQUISITION PROGRAM: MDA/SE

OBJECTIVE: Enable research scientists and engineers viable alternatives/options for optic materials used in Infrared weapons and sensors based upon a spectrum of operational thermodynamic environments.

DESCRIPTION: Optical technologies operating in current weapons systems and sensors are subjected to extremely harsh thermodynamic environments. Due to the high stress these materials are subjected to, material failure is high, diminished structural integrity is not uncommon, and replacement cost can be excessive. Lower cost solutions to these optical materials is necessary to reduce program cost while still retaining mission capability and IR transmission integrity.

PHASE I: Research and development on IR transmissive optics based on legacy products. These technologies should meet or exceed threshold transmissivity specifications of existing optical materials with a focus of low cost development and an experimental focus of extreme thermal impact on IR transmission through optical media and structural integrity.

PHASE II: Direct efforts to replace existing IR optical media in current and future weapon systems and sensors. Develop and test the new optical technologies. The development effort should consist of running the simulation for a variety of scenarios that take into account operational conditions weapons and sensor may be designed for, IR operational ranges, elevation, various weather conditions, etc.

PHASE III: Produce prototype IR window technologies for fielding in current and future systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Materials that prove to be useful optics have a variety of commercial applications such as commercial multi-spectral imagery satellite equipment lenses.

KEYWORDS: IR optics, imagery, sensors, weapon sensors, missiles, remote sensing optics.

MDA 03-060 TITLE: Methodologies For Rapid Software Integration, Test And Transition To An Operational State

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: MDA/SE

OBJECTIVE: Enable systems integration and test engineers to develop a means to effectively, efficiently and rapidly implement and transition software into a complex system.

DESCRIPTION: The effective utilization of software to control various functions within a system is paramount to its successful completion and implementation. Due to the number and increasing complexity of current systems being developed finding new techniques to reduce development time has become more important than ever. In order to meet development deadlines to bring systems more rapidly to an operational state, methodologies need to be created to facilitate and expedite software integration, test and transition.

PHASE I: Devise a methodology for rapidly integrating, testing and transitioning software to an operational state. This Methodology can include Modeling and Simulation Tools, stochastic techniques, etc.

PHASE II: Develop and test the methodology and or model and analytical tools. The methodology should be effective regardless of programming languages and should be applicable to a variety of applications and operating systems.

PHASE III: Prepare the methodology/process and the tools generated as a result of the analysis to be marketed for use in the government and private sector.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This rapid software integration, test and transition useful for any company that would wish to expedite their software development processes.

REFERENCES: None

KEYWORDS: Software, Analysis, Model, Statistics, Test, Integration, Transition, Methodology

MDA 03-061 TITLE: 3-D Modeling of Rocket Motor Plumes

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: MDA/SE

OBJECTIVE: Enable research scientists and engineers to analyze the physical behavior of a rocket motor plume based upon the multidimensional nature of the heat released and force generated from the exothermic chemical reactions of its fuel air mixture.

DESCRIPTION: 3-D Modeling and Simulation has been demonstrated as an effective and efficient means for determining and predicting the behavior of systems constituted of a broad and varied range of characteristics. Systems being analyzed are extremely complex with numerous factors that need to be taken into consideration. Higher fidelity and a more comprehensive means of performing modeling and simulation for rocket motor plumes will provide more reliable data and results. These results can give scientists and engineers insight into how they can improve propulsion efficiency by understanding the affect that various factors have on the development of the rocket motor plume.

PHASE I: Devise a methodology for creating a 3-D Modeling and Simulation Tool for Rocket Motor Plumes. This Modeling and Simulation Tool should be designed along with a practical means for performing a feasible analysis to accurately interpret the results.

PHASE II: Develop and test the 3-D Modeling and Simulation Tool and analysis approach. The development effort should consist of running the simulation for a variety of scenarios that take into account payload, elevation, various weather conditions, etc.

PHASE III: Prepare the 3-D Model to be marketed for use in the government and private sector.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This 3-D Rocket Motor Plume Model and Simulation could be utilized in the commercial aircraft industry to help improve fuel efficiency in their jet designs.

REFERENCES: None

KEYWORDS: 3-D Modeling and Simulation, analysis, rocket motors, plumes, propulsion, missiles

MDA 03-062 TITLE: <u>On-Orbit Longevity of Cryogenic Cooling Systems</u>

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

ACQUISITION PROGRAM: MDA/SE

DESCRIPTION: Lifetime and reliability are driving concerns for the use of active cryogenic cooling technology in space. Military, commercial, and scientific applications have driven the requirements for the development of long life (10+ years), high reliability cryocoolers for three decades. Although the overall scope of development issues for active refrigeration includes the mechanical cooling unit itself, the power conditioning and control electronics, and the software utilized for cryocooler operation, the current focus and greatest concern is the reliability of the mechanical cryocooler. Recent developments in the state of the art have vastly improved the current generation of cryocooler technology, but significant issues remain and chiefly center around the reliability of the devices utilized for long life mission applications. Quantifying the lifetime and reliability of long life cryocooler technology is elusive. Many of the mechanical refrigerators that have been developed, or are under development, are usually unique or have very low production numbers (1-2 units). Additionally, designs mature and evolve from cooler to cooler to accommodate new improvements or to meet emerging customer specifications. These changes affect the design heritage and any prediction of cryocooler reliability. One large unknown in the useful lifetime prediction for cryocooler performance is the long-term degradation components that are observed only over thousands of hours of operation. Innovative proposals should address design, manufacturing, producibility, and reliability issues for components and complete mechanical cryocoolers. Issues include, but are not limited to, close tolerances, flexing elements, high precision alignment, hermeticity, gaseous contamination, component and system qualification and testing could be addressed with the overall goal of enabling verification of reliable cryocoolers for space applications.

Phase I: Devise a scheme for prolonging the life span of cryogenic cooling systems. This scheme can involve stress analysis due to force members and thermal loading as well as material selection and materials processing.
Phase I SBIR efforts should concentrate on the development of the fundamental concepts for increased manufacturability, producibility, and reliability of space cryogenic coolers. This could include demonstration of a process or fundamental physical principle in a format that illustrates how this technology can be further developed and utilized in a cryocooler. This effort should include plans to further develop and exploit this technology in Phase II.

Phase II: Phase II SBIR efforts should take the innovation of Phase I and design/develop/construct a breadboard device to demonstrate the innovation. This device may not be optimized to flight levels, but should demonstrate the potential of the prototype device to meet emerging operational specifications. Develop and test longevity scheme and refine analytical techniques and approach. The scheme should be effective for multiple cryogenic systems and multiple system configurations. Demonstration of the potential improvements in manufacturability, producibility, and reliability of space cryogenic coolers should be included in the effort. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort.

Phase III: Typical MDA military space applications cryogenic coolers relate to infrared sensing, cryogen management, electronics cooling, and superconductivity. Potential Phase III opportunities to transfer this technology to emerging MDA programs include the Advanced Space Based Infrared System and block upgrades to the Space Based Infrared System Low, where a number of cryocoolers are planned to be built and fielded over a short build schedule.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The applications of this technology could potentially be far reaching with large market potential due to the increased reliability and expected reduction in cost for cryogenic coolers. Applications of this technology include NASA, civil, and the commercial sector for space based and airborne uses such as missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. The need for high reliability cryocoolers for terrestrial applications includes cellular bay station cooling and magnetic resonance imaging. Other potential applications include CMOS (complimentary metal-oxide semiconductor) cooling for workstations and personal computers.

References:

1. Davis, T. M., Tomlinson, B. J., and Ledbetter, J., “Military Space Cryogenic Cooling Requirements for the 21st Century”, Cryocoolers 11, R. G. Ross, Jr., Ed., Plenum Press, New York (2001), pp. 1-10.
2. Blankenship, S., Fountain, T., Davis, T., and Tomlinson, B. J., “Air Force Research Laboratory Cryocooler Reliability Initiatives”, Cryocoolers 11, R. G. Ross, Jr., Ed., Plenum Press, New York (2001), pp. 27-34.
3. Tomlinson, B. J., Yoneshige, C., and Abhyankar, N., “Air Force Research Laboratory Cryocooler Characterization and Endurance Update”, Cryocoolers 11, R. G. Ross, Jr., Ed., Plenum Press, New York (2001), pp. 17-26.
4. Hanes, M., “Performance and Reliability Improvements in a Low-Cost Stirling Cycle Cryocooler”, Cryocoolers 11, R. G. Ross, Jr., Ed., Plenum Press, New York (2001), pp. 87-94.
5. R. C. Bowman Jr., B. D. Freeman, et al., “Design and Evaluation of Hydrogen Joule-Thomson Sorption Cryocoolers”, Proceedings of the International Absorption Heat Pump Conference, New Orleans 19-21 Jan 1994, p. 265-271.
6. Nellis, G., F. Dolan, W. Swift, and H. Sixsmith, "Reverse Brayton Cooler for NICMOS," Cryocoolers 10, R. G. Ross, Jr., Ed., Plenum Press, New York (1999), pp. 431-438.
7. Ruffin, P. B., and Burgett, S. J., “Recent progress in MEMS technology development for military applications”, Proceedings of SPIE - The International Society for Optical Engineering; ISSN: 0277-786X, Mar 2001; v.4334, p.1-12.

KEYWORDS: Cryogenic, Cooling, Analysis, Methodology, Materials Science, Outer Space, Orbit,

MDA 03-063 TITLE: <u>Decision Support Tools for Capability-based Systems Engineering</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: MDA/SE

OBJECTIVE: Enable decision-makers to effectively manage the complexity of acquisition investments under uncertainty in a consistent and quickly repeatable fashion

DESCRIPTION: The complexity of missile defense systems engineering and integration problems demands a systems thinking approach that can readily cope with much more uncertainty than traditional methods. In Capability-based Acquisition there is no established requirement on which to base traditional cost-benefit analyses due to the uncertain political, military, economic, and technical environments. Computer Aided Systems Engineering (CASE) tools, such as an intelligent decision aid systems toolbox, are needed to facilitate capability-based systems engineering. Bayesian decision theory is believed to provide the necessary firm grounding for the process of comparing and evaluating alternative system designs with respect to how well they meet technical objectives and goals given potential adversary capabilities and demonstrated development progress. These results of a tool based on Bayesian decision theory can give decision-makers a better idea of how further enhance the system

PHASE I: Devise a decision-making tool based on Bayesian decision theory. This decision-making tool should be designed along with a practical means for performing a feasible analysis to accurately interpret the results.

PHASE II: Develop and test the decision-making tool. The development effort should consist of running the decision-making tool for a variety of scenarios that involve uncertain political, military, economic, and technical environments.

PHASE III: Prepare the decision-making tool to be marketed for use in the government and private sector.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The decision-making tool could be utilized by system engineers that are in the aircraft, automotive or computer industries.

REFERENCES: None

KEYWORDS: Bayesian, Tools, Modeling, Simulation, Capability-based Acquisition, CASE

MDA 03-064 TITLE: Lightweight, High-Precision Inertial Reference Unit

TECHNOLOGY AREAS: Space Platforms, Weapons

ACQUISITION PROGRAM: MDA/SL

OBJECTIVE: Develop a lightweight, high precision inertial reference unit for long-range acquisition, tracking and pointing applications.

DESCRIPTION: Proposed MDA systems such as Space Based Laser (SBL) and space based surveillance systems share a common objective: extremely high resolution Line of Sight (LOS) stabilization for target imaging. In order to achieve the mission objectives, their active acquisition, tracking and pointing (ATP) subsystem must provide precise LOS pointing and tracking capabilities with suppression of LOS jitter. An inertial reference unit (IRU), in the context of the ATP mission, provides an inertially stabilized platform containing an optical probe beam that provides a precise pointing and tracking reference for the pointing system. This system is required to have nanoradian jitter performance. The IRU serves as a master reference for stabilizing imaging and weapon system pointing and tracking. Future IRUs will be required to achieve 5 nanoradian rms jitter stabilization performance in the presence of base motion disturbances. The device must be able to maintain its inertial reference through large angle slews of the space vehicle (up to + 180 degrees) and have the ability to perform precision slewing of the inertial platform containing the optical probe beam relative to its base through + 250 microradians to support tracking and pointing operations. The Government is specifically interested in enhancement of four critical components associated with an IRU system: (1) Sensors, (2) actuators, (3) flexure system, and (4) electronics. Due to the complexity and scope of this problem, the contractor may elect to propose on any component(s) or the entire system.

Sensors: In current IRU designs, the sensors are located on the platform to be inertial stabilized. As a result, we require extremely high accuracy, lightweight, small volumetric footprint sensors. Performance goals are (1) drift of 0.001 degrees/hour, (2) angular random walk (ARW) of 0.0005 degrees/root hour, (3) Scale factor stability of 500 ppm (3 s), (4) bandwidth of 1 kHz. The resolution of the sensor should ensure that the platform noise level can be achieved. The slew rate of the platform will be up to 0.2 rad/sec. If the sensors are subjected to a linear shock of 0.1 g's the instrument should not saturate. Any saturation of the instrument should recover within 10 milliseconds after the high level is removed.

Actuators: The sensors should be very noise free, a noise of less than 0.5 x 10-9 meters is required (5 nanoradians over a 4 inch lever arm). There should be very low radiated electromagnetic noise and the bandwidth should approach 1kHz. The actuators must have sufficient control authority to slew the inertial platform containing the inertial sensors and optical probe beam on its flexure system through the range of motion at the required rates.

Flexure system: It is very important to achieve linearity of the flexure. The spring rate will be compensated using the actuators, but the linearity must insure linear compensation is possible. The total travel in the flexure should be at least 250 microradians. The flexure system will support the inertial platform containing the inertial sensors and optical probe beam. Designs should address steps taken to minimize parasitic resonances that could adversely effect the control system design. As the system may be used for on-orbit applications, how launch loads will be handled should be addressed.

Electronics: The electronics must be very low noise insuring that the 5 nanoradian noise level can be achieved. Also they must not radiate any electromagnetic noise, and should be as small as possible to permit the electronics to be packaged closely to the platform. Terrestrial, airborne and space-based application issues should be addressed.

PHASE I: Develop component(s) and/or system to the conceptual design level with supporting modeling, simulation and analysis to demonstrate feasibility of approach.

PHASE II: Perform preliminary and critical designs of component(s) and/or system and construct an engineering development unit. Demonstrate component and/or system capability through testing. Outline the benefits and potential problems with the proposed configuration. Estimate production costs.

PHASE III/DUAL USE: IRUs provide extremely high resolution Line of Sight (LOS) stabilization for target imaging. This has considerable military application to SBL, ABL, THEL, etc. An advanced lightweight IRU would also greatly improve image quality on next generation commercial satellites, NASA imaging satellites, and other applications where optical alignment is critical.

REFERENCES:
1. Walter, R.E.; Danny, H; Donaldson, J., "Stabilized Inertial Measurement System (SIMS)", paper 4724-10, Laser Weapons Technology III, SPIE, Aerosense Conference, April 2002.
2. "Preliminary Design of the Inertial Pseudo Star Reference Unit", T.T. Chien, et al, The Charles Stark Draper Laboratory, Phillips Laboratory, AFMD, Kirtland AFB, NM, USAF, Final Report PL-TR-91-1058, September 1992.
3. "Interface Control Document (ICD), Inertial Pseudo Star Reference Unit (IPSRU) to the High Altitude Balloon Experiment (HABE)" Draper Document No 307881 Rev B, X92214129, 18 Feb 1994.
4. "High Altitude Balloon Experiment (HABE) Program", Joseph C. Krainak, Technical Report, Improved HABE Control Loop, DC-TR-5001.211-4, Prepared by ITT Industries, Albuquerque, NM, Submitted to AFRL, Phillips Research Site, Space Vehicles Directorate, Kirtland AFB, NM 87117.

KEYWORDS: Inertial Reference Unit (IRU), Acquisition, Tracking and Pointing (ATP), gyros, inertially stabilized platform, beam control.

MDA 03-065 TITLE: Thermal Management System for Solid State Lasers

TECHNOLOGY AREAS: Space Platforms, Weapons

ACQUISITION PROGRAM: MDA/SL

OBJECTIVES: Develop a thermal management system for high power solid-state lasers.

DESCRIPTION: Solid-state lasers have potential use in Space-Based Lasers (SBL) and Airborne Lasers (ABL) as target illuminators, aim point designators or beacons, or as high power weapon class lasers. A serious limitation for the scaling and use of solid-state lasers is the management of waste heat on board an aircraft or satellite. For high power concepts to succeed in improving the overall energy efficiency and waste heat management, certain tasks must occur in the following areas: heat must be rejected from diode lasers and heat must be from the solid state laser gain medium. This will enable good beam quality for the laser beam and to regulate/transfer the waste heat to the outer environment. In general, the overall wall plug efficiency of these devices approaches 5-8% when a thermal management system is included. This estimate assumes state of the art performance of the pump diode laser of 50%, of optical to optical conversion of 40%, electronic conversion of 90%, and a factor of 2 performance degradation due to a cooling system. An example of the regulation of waste heat is a heat storage device, which may be necessary to accommodate large but short time duration heat production due to the short duty cycle demands of the laser system. Examples of the environment of the platform for the laser device may be deep space from a satellite or cool airflow on board an aircraft.

PHASE I: Develop a conceptual design for a scaleable thermal management system for performing one or more of the objective applications. The system will have a performance goal of 30-minutes of continuous operation for a 1-kW laser system. Define its feasibility with supporting analyses, requirements, and critical data needs.

PHASE II: Build and demonstrate a prototype system to validate the1-kW laser system. The results will be used to validate scaling models.

PHASE III/DUAL USE: SBL and ABL project future requirements to systems up to 100-kW and beyond. Phase II design will be scaled to meet future requirements. Potential commercial uses include remote sensing lidar and illuminator systems especially located on mobile platforms, for terrestrial and space communication application, improving the beam quality of commercial laser systems, and enable scaling to large scale laser machining systems.

REFERENCES:
1. B. L. Freitas, J. A. Skidmore, J. Crawford, J. Santariano, E. Utterback, L. DiMercurio, K. Cutter, K. Kranz, S. Sutton, and R. J. Beach,“Laser diode packaging at LLNL, the Next Generation”, paper DP-6, Technical Digest 14th Solid State and Diode laser Technology Review, May 21-24, 2002, Directed Energy Professional Society,
2. D. P. Rini, H. R. Anderson, L. C. Chow, M. Bass, J. L. Lindauer, and T.Y. Chung, “ Spray colling of High Power diode Laser Arrays”, paper DP-7, Technical Digest 14th Solid State and Diode Laser Technology Review, May 21-24, 2002, Directed Energy Professional Society,

KEYWORDS: Thermal management, solid state lasers, diode-pumped solid state lasers

MDA 03-066 TITLE: Laser Dynamic Disturbance Mitigation

TECHNOLOGY AREAS: Space Platforms, Weapons

ACQUISITION PROGRAM: MDA/SL

OBJECTIVE: Demonstrate technology for vibration mitigation for plumbing flows on optical payloads such as high-energy lasers.

DESCRIPTION: Sophisticated optical payloads, such as a space-based laser, which demand the maintenance of sensitive alignments or the accurate pointing of an optical axis can suffer greatly from the dynamic disturbances generated by reactant fluid flows. For example, this can be the case for a chemical laser, or even thermal fluids for certain thermal management concepts for solid state lasers. These disturbances originate from the random pressure fluctuations of turbulent fluid flow and the unsteady eddy motions generated at corners or constrictions [Au-Yang]. Fluid disturbances are in turn transmitted to the vehicle structure through wall boundaries [Au-Yang] and therefore to optical components of the payload [Graffer]. In a laser, these vibrations degrade wavefront quality due to temporal misalignments and contribute significantly to the jitter of the laser beam. Innovative technology that is compact in mass, compact in volume, cost effective, scalable, and possibly space qualifiable is sought for "quieting" the high flows of gaseous fluids such as helium, hydrogen, and nitrogen through pipes, bends and elbows, tees, and constrictions such as valves, distribution manifolds, and metering orifices. Solution may include tailoring of the geometry and surfaces of pipes or the insertion of clever devices to change a local state of turbulence.

PHASE I: Development of conceptual design and possibly some fabrications of concepts is expected this phase. Concepts may include application to straight cylindrical pipes, bends, elbows, tees and manifolds. Proposed approaches are to be useful at conditions in delivery pressure and flow-rates applicable to high power laser or thermal management devices, or should be shown to be scalable to the relevant conditions. Contractor may consider documenting the degree of improvement by testing. Design details, proposed test plan, and a proposal for Phase II are the expected products.

PHASE II: Complete fabrication of components and devices necessary to mitigate fluid flow vibration. The facility for any demonstration testing is to be completed. New components and devices are to be integrated into test articles for the test program. Measure of success of the innovations will be significant degrees of attenuation in vibrations in the frequency range important to laser beam control. Products to be delivered shall be the devices and the completed test report.

PHASE III/DUAL USE: The immediate advantage of this work lies in utility for vehicular optical payloads for surveillance but especially high power lasers, in space, air, land, or sea. The work should be of particular importance and interest to the SBL, ABL, ATL, and MTHEL programs. Cost effective vibration control of fluid flows will be of broad general interest in many commercial industries, particularly for large-scale heating and cooling and environmental machinery and distribution systems that generate vibration and noise.

REFERENCES:
1. M.K. Au-Yang, Flow-Induced Vibration of Power and Process Plant Components, American Society of Mechanical Engineers, New York, NY, 2001, 478 pp but especially Ch. 4, 5, 6, 10.
2. A. Graffer. "ALPHA I Disturbance Measurement Final Report," A2-9249, 17 Aug. 1989.

KEYWORDS: laser dynamic disturbance, dynamic disturbance, flow vibration, vibration, vibration control, high-energy lasers, space vehicles.

MDA 03-067 TITLE: <u>Non-linear Optical Beam Correction</u>

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: MDA/SL

OBJECTIVES: Develop a non-linear optical wavefront correction system.

DESCRIPTION: Space Based Lasers (SBL) and Airborne Lasers (ABL) require high brightness to achieve optimized performance of energy on target at minimum design weight. The brightness is achieved using large beam expanders to project energy at range and by minimizing wavefront error (WFE) on the laser beam. The time dependent pointing stability (jitter) must also be controlled accurately. These are difficult feats to achieve for space vehicles given the space thermal environment, the complexity of the beam train, and the potentially wide bandwidth vibrations caused by the gas flows in the laser or on the beam train. Passive nonlinear optical phase conjugation methods have demonstrated the ability to dramatically improve wavefront and beam quality with improved jitter performance. Correction of an aberrated target image may be needed in the targeting loop to determine the aimpoint on the target. The correction is necessary to remove aberrations introduced by the large optics or by the atmospheric path. Half of the estimated cost of a SBL is the optical payload that consists principally of the beam expander and beam control elements. These elements must be able to control the WFE to within a fraction of a wavelength across large surfaces of 4-12 m for the target loop and to perform wavefront correction for the laser beam. Nonlinear optical methods may allow the use of lightweighted optics that are easier to fabricate and simplified control systems in future systems at significantly reduced cost and risk. Submissions must address one or more of the following applications, (1) wavefront correction of a high power laser itself leading to high Strehl, (2) target image correction for the purpose of surveillance such as aimpoint selection or discrimination, and (3) wavefront correction of an outgoing high power laser beam due to optical distortions in subsystems such as the beam director.

PHASE I: Develop a conceptual design for a nonlinear optical system for performing one or more of the wavefront correction applications. A feasibility demonstration shall be defined with supporting analysis of correction capability as a function of temporal and spatial bandwidths. If possible supporting data should be collected if needed. Proof-of-concept prototypes are highly encouraged.

PHASE II: Develop a subscale prototype for scaling experiments to larger apertures, higher power, and higher temporal bandwidths. The experiments shall be performed to collect data that will be used to validate the correction capability of the four-wave system. If the application is for the correction of a laser beam, a design of a wavefront correction system shall be built and demonstrated. For the application of target loop correction, design of either a 1.5 m or a 4 m class beam director for an airplane platform or space platform respectively shall be performed.

PHASE III/DUAL USE: Transition to larger scale testing is intended to result in a validated engineering design and demonstration at either higher power (several hundred watts) or physical scale size. Direct application is wavefront control of space-based laser and Airborne Laser with specific emphasis on Hydrogen Fluoride (HF), Hydrogen Fluoride Overtone (HF-OT), and Iodine Lasers. Potential commercial uses include material processing for manufacturing of semiconductor or MEMS manufacturing, remote sensing including lidar systems, improving the beam quality of commercial laser systems, improving link margin for lower power laser communications, and lowering the cost astronomical laser guide star systems.

REFERENCES:

1. T. R. O'Meara, D. M. Pepper and J. O. White,"Application of Nonlinear Optical Phase Conjugation" in Optical Phase Conjugation, edited by R. A. Fisher, Academic Press, 1983
2. V. E. Sherstobitov, V. P. Kalinin, D. A. Gryachkin, N. A. Romanov, S. A. Dimakov, and V. I. Kuprenyuk, "CO2 Lasers and phase conjugation", in Proceedings of SPIE vol 1415, Modeling and Simulation of Laser Systems II, Bellingham, WA, 1991.
3. E. L. Bubis, O. V. Kulagin, G. A Pasmanik, and A. A. Shilov, "Possibilities for correcting aberrations of imaging laser systems by phase conjugation," Appl. Optics 33, 5571(1994)
4. A.A. Leshchev, V. G. Sidorovich, M. V. Vasilev, V. Y. Venediktov, and G. A. Pasmanik, "Nonreciprocal optical systems with phase-conjugating mirrors-a new class of optical imaging system," Internat. J. Nonlinear Opt. Phys. 3, 89(1994).
5. A. A. Betin, S. C. Matthews, M. S. Mangir "Vector phase conjugation with loop laser geometry", paper CTuL4, Proceedings of CLEO, 1997.

KEYWORDS: Local Loop laser beam control, target loop correction of images, outgoing beam control, four wave mixing.

MDA 03-068 TITLE: Hybrid Vibration Isolation System for Whole-Spacecraft Launch Protection

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: MDA/SL

OBJECTIVE: Develop a hybrid whole-spacecraft isolation system for Minuteman and Peacekeeper derived launch vehicles.

DESCRIPTION: Passive whole-spacecraft vibration isolation systems have recently been flight demonstrated and proven effective at reducing the effect of the harsh vibration environment satellites experience during launch. The development of new launch vehicles using surplus ICBMs has increased the need for isolations systems. The ICBMs were designed to loft robust re-entry vehicles towards their targets. Satellites are much more fragile than the design payload of the ICBM. In addition, these missile systems were designed to be storable and instantly ready driving designs using solid rocket motors resulting in a much rougher ride than a liquid rocket motor design. Finally, these systems were designed to employ high-energy trajectories that got the missile away from the silo in order to avoid in-coming missiles aimed at destroying the ICBM in the silo. All of these factors result in a much rougher ride for a satellite payload launched on a surplus ICBM. There is currently an existing Space Launch Vehicle (SLV) that uses Minuteman II motors and a Peackeeper derived SLV procurement is in the final planning stages. Continued development of these systems is crucial to allow the use of the lower cost ICBM derived launch vehicles and provide significant reliability improvements to all satellites by subjecting them too much lower launch environment. Payloads such as space lasers and other space-based optical systems require a benign ride because of the extremely tight alignment required of optical components. Certain space laser concepts under consideration also require low cost launch vehicles to allow development and test of their systems at a reasonable cost. A three-fold reduction in launch loads are required to allow space laser development programs to take advantage of the lower cost ICBM derived vehicles. Several factors limit the performance of passive systems. The first is that the effectiveness of the system at lower frequency regimes (< 20Hz.) is limited because the isolation system is designed to operate at higher frequencies to avoid adverse coupling with the launch vehicle guidance system. The second is that current isolator design allows too much lateral movement within the payload dynamic envelope allowed within the launch vehicle fairing. The final limitation is that the isolator might not protect from the initial load (potentially beyond the capability of space laser design limits) due to a lagging response from the passive systems. To address these limitations and dramatically increase the performance of future launch vibration isolation systems, innovative ideas are sought for a hybrid active/passive vibration isolation system aimed at the ICBM derived SLVs.. The proposed system should offer dramatically improved performance over state-of-the-art passive launch isolation systems. It should be reliable, be readily adapted to existing spacecraft adapter systems, and draw minimal power.

PHASE I: Develop hybrid isolation system concept. Demonstrate feasibility through modeling and simulation under realistic constraints and loads. Proof-of-concept prototypes are highly encouraged.

PHASE II: Construct an engineering development unit of the hybrid isolation system. Demonstrate critical component capability through testing. Outline the benefits and potential problems with the proposed configuration. Estimate production costs.

PHASE III: Full Scale Engineering Development

REFERENCES:
1. Cross, L.B., Fox, G.L., Van Ert, D.L. "Guidelines for Procurement, Qualification, and Acceptance Testing of Dynamic Isolators and Isolated Components." 14th Aerospace Testing Seminar Proceedings, Mar 9-10, 1993, Mount Prospect, IL. 1993. Pages 235-240.
2. Donovan, J.B., Auslander, E.L. "The use of Vibration Isolators to Reduce Aerospace Subsystems Weight and Cost." Aerospace Design Conference Proceedings, Feb 16-19, 1993, Irvine, CA Feb 1993. AIAA PAPER 93-1146.
3. Dolbeare, R. "Vibration Isolation System Development for the FB-111 Tail Pod Electronics." Journal of Environmental Sciences, V.25, Nov-Dec 1982. Pages 34-40.
4. "Load Analysis of Spacecraft and Payloads" NASA-STD-5002, June 21, 1996
5. Spacecraft and Launch Vehicle Dynamics Environments Technical Interchange Meeting. September 10-11, 1996, Chapters 9-13.

KEYWORDS: Isolation, hybrid, dynamic vibrations, Spacecraft Protection, Launch Vehicles.

MDA 03-069 TITLE: Deployment Mechanisms for Precision Optical Systems

TECHNOLOGY AREAS: Space Platforms, Weapons

ACQUISITION PROGRAM: MDA/SL

OBJECTIVE: To develop high-stiffness, low-hysteresis mechanisms with optical-quality precision for use with large deployable optics.

DESCRIPTION: The desire for ever-larger telescopes in space mandates the ability to launch telescopes in a stowed condition and then deploy them on orbit. This need applies to multiple missions, including Space-Based Laser (SBL), NASA astronomy missions, and surveillance missions. These mechanisms must accommodate large, heavy mirror segments, but must perform to optical tolerances. Development efforts to date have shown the difficulty of designing and building suitable latches and hinges. Deployed stiffness achieved has been less than one million lbs/inch, while the expected need is 3-5 million lbs/inch. In addition to stiffness, the mechanisms must exhibit very low hysteresis (that is, they must not change positional states because of on-orbit thermal or loading changes), and their response to loading in the deployed state must be nearly linear (to enable accurate modeling). A possible future space-based laser will have a primary mirror in the 8-10 m diameter range. With payload fairings limited to 4.5 m for the foreseeable future, deployable optics are required. Current concepts contain a segmented mirror with one center segment and 6-8 petals. Deployment schemes are varied, but all concepts require similar mechanisms to be feasible. Mechanisms meeting the requirements have not been demonstrated, and current efforts have shown the difficulty involved. Most mechanisms developed to date are proprietary, but approaches explored have included highly-preloaded friction joints, bearing-based non-Hertzian type joints, SMA hinges, and meltable metal alloy hinges. Innovative designs and approaches are clearly required to meet these demanding requirements.

Specific requirements for these mechanisms include the following:
-Individual petal size: 45 – 60 degree pie-shaped segment of 10-m aperture, less a 2.4-m central segment
-Individual petal weight: 400 – 550 kg
-Qty of mechanisms per petal: 3
-Stiffness: > 3,000,000 lbs/inch
-Hysteresis: < 0.015 micro-inch / lb
-Linearity: > 90%

PHASE I: Develop design(s) and analytical performance predictions of proposed mechanisms. Demonstrate feasibility in a brassboard experimental test. Develop fabrication approaches and test plans.

PHASE II: Design and fabricate a full-scale prototype. Develop test plans to characterize the mechanism's structural (strength and stiffness) characteristics, hysteresis, linearity, stability, deployment precision, and repeatability. Compare experimental results to simultions/analyses. Identify any anomalies and their root cause.

PHASE III/DUAL USE: Populate a deployable primary mirror in a structural test bed, approx. 24 hinges/latches, or provide flight hardware for deployable system, depending on results and maturity to date. Mechanisms would be applicable for any large space-bound telescope, including NASA astronomic or DoD surveillance, in addition to SBL. Terrestrial applications include ground-based deployable optics.

REFERENCES: B. Helgesen, "High Stiffness Latching of Deployable Space Structure Joints Using Melting Metal Technology," AIAA 2001-4587, Space 2001 Conference, Albuquerque, NM.

KEYWORDS: Mechanisms, Deployable Optics, Low-hysteresis, Hinges, Latches, Precision Deployment, Repeatability

MDA 03-070 TITLE: On-Orbit Servicing Fluid Couplings

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: MDA/SL

OBJECTIVE: The objective of this SBIR is to develop high pressure, repeated autonomous mate/de-mate fluid couplings for HF laser reactant resupply on-orbit.

DESCRIPTION: The ability to perform on-orbit servicing of space assets, and refuel in particular, has great potential benefits to increasing mission lifetime and utility. The capability to replenish liquids and gasses has utility to nearly every orbital propulsion system. These refueling capabilities are enabling to a Space Based Laser (SBL) system where assets may need to be able to perform multiple orbit maneuvers and to fire numerous shots over its lifetime. The cost and logistical support to provide such a capability drive the requirement to be able to replenish these consumables. One of the technologies key to performing a refueling mission is a fluid coupler that can be mated and de-mated numerous times by an autonomous system. It must be able to handle various liquids and gasses over a wide temperature and pressure ranges. The coupler also cannot leak because of payload contamination and attitude control. Fluids that are to be considered include, but are not limited to: nitrogen fluoride (NF_3) at 300K and 2800psia, deuterium (D_2) at 80K and 6500psia, molecular hydrogen (H_2) at 80K and 6500psia, helium (He) at 80K and 6500psia, and hydrazine (N_2H_4) at 300K and 350psia. Failure modes will be identified and may include misalignments or improper mechanical loading, contamination prior to coupling, mechanical fatigue from thermal cycling, trapped volumes of high-pressure gas, and other design specific conditions. All these conditions may lead to leaks or even ruptures. Diagnostic methods and associated sensors and software shall be designed to mitigate failures and ensure proper function. Incorporation of the diagnostics will be included in the design and testing.

PHASE I: Phase I will consist of a period of research into the state of the art of flight qualified and flight qualifiable high pressure fluid (liquid and gas) couplings such as those used in the Shuttle Cargo Bay to resupply the Manned Maneuvering Unit. Requirements shall be developed for fluid compatibility, pressure, temperature, transfer rate, reliability, repeated autonomous mate/de-mate capability, and leakage criteria as a minimum. Concepts will be developed to adapt and flight qualify any existing coupler designs identified. New designs will be generated for capabilities that do not exist, incorporating any existing capabilities. Development and flight qualification plans for new concepts will be outlined. An assessment will be made of state of the art methods and equipment for transferring laser reactants such as nitrogen trifluoride. Requirements will be developed for passivation and special handling both for ground operations and on orbit.

PHASE II: Phase II will consist of the development and testing of various connectors identified in Phase I. Handling and operating procedures will be developed and documented to enable autonomous operation in a refueling mission. Where possible, specific mission requirements, both government and commercial, will be used as design guidelines.

PHASE III/DUAL USE: Commercial spacecraft fluid replenishment necessary for most on-orbit servicing missions. Terrestrial applications include aircraft, automotive, and various industrial processing and handling processes; particularly for hazardous operations that require high reliability and/or automation.

REFERENCES:

1. On-Orbit Servicing, Donald M. Waltz, Kreiger Publishing Company, Malabar, FL, 1993
2. “Logistics Requirements for Space: On-Orbit Servicing (OOS)”, Bob Dellacamera, Donald Wlatz, Fred R. Spates, Glen Smith, Jeffrey L. Wampler, Daniel A Gallton, John Ianni, Unlimited Distribution Final Technical Report AFRL-HE-WP-TR-2000-0095, copies obtainable from: National Technical Information Service, 5285 Prot Rolay Road, Springfield, VA 22161.

KEYWORDS: On-orbit servicing, fluid couplings, refueling, high pressure, fluid transfer

MDA 03-071 TITLE: Spacecraft Separation System

TECHNOLOGY AREAS: Space Platforms, Weapons

ACQUISITION PROGRAM: MDA/SL

OBJECTIVE: To develop an innovative low-shock, non-pyrotechnic spacecraft separation system that can uniformly distribute the load of the spacecraft into the supporting structure.

DESCRIPTION: Current spacecraft are released from the payload adapter by a variety of separations systems that consist of clamp bands, discrete points, etc. The use of discrete points at various locations on the spacecraft/adapter can induce high stress concentrations at these attachment points caused by the spacecraft mass, launch loads, and the shock from the separation release. Depending on the shape, mass, and size of the spacecraft, these stress concentrations can result in major design challenges for the spacecraft designer. This effort will concentrate on developing a new revolutionary approach of spacecraft separation system that will alleviate these design concerns. One possible solution to this problem is to design the separation system to be a continuous joint along the interface between the spacecraft and the adapter and fracture the joint. Areas of consideration include reliability, tip-off, safety, contamination, low-shock, non-pyrotechnic, and low cost, manufacturability, and integration. It is also desired, if practical, that the systems have in-situ reset capability allowing the device tested to be the one that is flown. The desired capabilities are a factor of 5 reduction in peak shock and separation times that meet the requirements of that launch vehicle.

PHASE I: Develop conceptual designs of the mechanism based on preliminary analysis. Perform sufficient hardware development and testing to insure that the system requirements can be met. Proof of concept demonstrations shall be conducted to indicate the practicality of the design in meeting operational requirements and objectives. A comprehensive review of small satallite requirements will also be performed.

PHASE II: Finalize the mechanism design and validate its performance by meeting Air Force requirements. Develop and demonstrate full-scale operational flight hardware for a specific satellite. Demonstrate scalability of the hardware for satellites of different sizes and functions.

PHASE III/DUAL USE: Commercial and military applications exist for the development of spacecraft separation systems that are low-shock and non-pyrotechnic. Military applications include programs such as the SBIRS and the AF's Space Test Program (STP). These technologies developed to separate satellites from their launch platform can be directly transitioned to commercial satellite and launch systems.

REFERENCES:
1. Eugene R. Fosness, Waylon F. Gammill, and Steven J. Buckley, "Deployment and Release Devices efforts at the Air Force Research Laboratory Space Vehicles Directorate," AIAA Space Conference & Exposition, Albuquerque, NM, August 2001.
2. Peffer, A., Fosness, E., Capt Hill, S., Gammill, W., and Sciulli, D., "Development and Transition of Low Shock Release Devices for Small Satellites," presented at 14th Annual AIAA/Utah State University Conference on Small Satellites, Logan, Utah, Aug 23 – 26, 2000.

KEYWORDS: Spacecraft, Low-Cost, Mechanisms, Separation, Launch Vehicle, Low-Shock, Non-Pyrotechnic

MDA 03-072 TITLE: Small Payload Support Module

TECHNOLOGY AREAS: Space Platforms, Weapons

ACQUISITION PROGRAM: MDA/SL

OBJECTIVE: Develop Launch Vehicle Small Payload Support System that enables experimental payload launch into earth orbit.

DESCRIPTION: The USAF uses a wide range of launchers to loft payloads into orbit. Typically, these payloads, especially the experimental or prototype satellites, do not fully use the entire mass capability of the Launch Vehicle (LV). Sometimes some of this excess capability is used to loft secondary payloads with their own dedicated attachment fittings. Despite this there is still a critical shortfall of funding and launch opportunities for all of the experiments awaiting launch. It is imperative that new ways are found to use the excess capacity of existing launchers in a cost effective manner to get useful mass (testbeds, structures, components, hardware, etc) into orbit. The challenge is thus to find innovative concepts for the development of a Small Payload Support Module (SPSM) or spacecraft bus that will enable placement of Small Payload Systems (SPS) and their primary and secondary payload accommodations into orbit with minimal impact on existing launch systems. Successful SPSM concepts should be easy to integrate onto existing launcher hardware and provide an affordable way for the USAF to augment its ability to quickly and cheaply provide space test flight for experimental payloads. The core of an envisioned SPSM SPS launch experiment could include the following:

· Use of a SPSM container/structure (possible composite) to react the launch loads and interface to the existing fittings at the LV plane and also provide a structural interface for the payloads.
· Cmmand/Control and data acquisition and processing systems.
· Snsors (strain gages, accelerometers, force transducers, microphones, orbital orientation detection, etc) and signal conditioning.
· Regulated 28VDC power system
· Command uplink and data down link using existing or additional telemetry systems (might require collaboration with launch provider).
· Attitude control system.
· Thermal control system for the payload support module hardware.
· Deployment release systems
· Separation systems
· Integrated or auxiliary propulsion or kick motor systems.
· Potential experiments that could be enabled by a SPSM include those of the DOD Tri-Services Experiment Review Board payload list as well as others.

PHASE I: Establish feasibility of concept based upon evaluation of such issues as launch/acoustic/shock load survival, interfacing with existing rocket mechanical attachment points, power, electro-magnetic compatibility, telemetry, and useable volumes, over a range of existing launchers. Candidate launchers to be considered should include Taurus, OSP/Minotaur, and upcoming EELV's. Develop conceptual SPSM design and test plan. Provide simulation/demonstration of basic concepts.

PHASE II: Finalize design based on a selected launcher. Design, build, and test demonstrate SPSM based upon Phase I test plan. Depending on funding, support potential launch and on-orbit checkout/use.

PHASE III/DUAL USE: Utilize this SPSM in any number of programs from the Space Test Program (STP) that require the use of a small bus to maximize excess capacity and get useful mass into orbit. There is a large commercial market for small payload support modules using commercial launch vehicles. SPSMs will be ideal platforms for low cost flight of small payloads, for R&D, technology demonstration and small operational satellites.

REFERENCES:
1. Haskett, S., Sciulli, D., Huybrechts, S., Fosness, E., Meink, T., Maly, J., and Doggrell, L., "EELV Secondary Payload Adapter (ESPA)," 13th Annual AIAA/Utah State University Conference on Small Satellites, Logan, Utah, Aug 23 – 26, 1999.
2. Ganley, J., "Structural Issues associated with the University Nanosatellite Program," SEM 2000 Conference, Orlando, FL, June 6-8, 2000.
3. Small Satellite Performance Study, G. T. Harkness, The Aerospace Corporation, ATM-95(5514-03)-3
4. SACI-1 A Cost Effective Microsatellite Bus for Multiple Mission Payloads, J. A. Neri et. al., INPE, International Conference on Small Satellites, Mission and Technology, 9-13 September 1996, Madrid, Spain

KEYWORDS: Satellite, Module, Spacecraft, Space Standardized, Smallsat, Microsat

MDA 03-073 TITLE: <u>Multiple Purpose Photodiode Array</u>

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: MDA/SS

OBJECTIVE: To develop a high speed, two-dimensional, photodetector array with high sensitivity, wide spectral range, high frequency response, and low cross talk.

DESCRIPTION: Recent advances in the design of photodetector arrays have been achieved mainly due to developments in high-resolution CMOS (complementary metal oxide semiconductor) and CCD (charge coupled device) technology for cameras. Despite their many advantages over arrays of conventional photodiodes, CMOS and CCD devices have a number of shortcomings that limit their use in laser sensing, imaging, and other applications in support of BMD mission. In any of these applications, photographic spatial resolution is not required. Instead, a high frequency response combined with high quantum efficiency over a broad spectral range, and the possibility to rapidly and randomly address any pixel is often of major importance to BMD application. A photodiode arrays may satisfy these requirements and can be built on a single crystal with a pitch as small as 10 um and an element size of greater than 5-um in diameter. The array size could be up to 25x25 elements. Research and development efforts are necessary to provide competitive performance parameters for the device: high responsivity over the entire spectral range from the Visible to Near IR; small cross-talk even with small element sizes and pitch; and wide frequency and dynamic range. It may also be possible to tune the spectral sensitivity (quantum efficiency) to optimize performance at a particular wavelength.

PHASE I: The contractor will demonstrate the feasibility of a prototype photodetector array with 25x25 elements, sensitivity from the visible to the near IR, quantum efficiency greater than 80%, cross-talk between elements less than 5%, and improved resistance against hazardous environments. Research efforts will emphasize the areas of detector responsivity (quantum efficiency), and tuning the design to provide the maximum possible quantum efficiency (approximately 90%) at the wavelength of interest. The signal-to-noise ratio will be optimized for the lowest possible Noise Equivalent Power (NEP) value at each wavelength of interest. The overall design will also address the issue of photodetector performance in the hazardous environments of high radiation levels and high or low temperatures. Cryogenic coolers could also be used to improve the photodiode array performance.

PHASE II: In Phase II, the contractor will build and deliver a prototype detector array with adequate test and measurement of its performance envelop.

PHASE III: This two-dimensional detector array can be used widely for a variety of military applications, including surveillance, satellite tracking, advanced lidar systems, etc.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Commercially, this array will be useful in areas such as non-destructive inspection, laser beam profiling, and communications.

Reference:
1. O. Yadid-Pecht, B. Minch, B. Pain and E. Fossum, "Augmented Active-Pixel Sensors Would Compute Centers of Mass", NASA Tech Briefs issue, vol. 22 No. 10, Oct 1998.
2. McCarty, C.Sun, and C. Ho, "Integrated Imagers with CMOS Active Pixel Sensors": Present, Past and Future, AIAA Defense and Civil Programs Conference, Huntsville, Oct 28-30, 1998.
3. Burns, H.N., Steiner, M.T., Hayden, D., "Compact, 625-channel Scannerless Imaging Laser Radar Receiver". Proc. SPIE, vol.2748, p.39-46, (1996).
4. T. Shaw, B. Pain, B. Olson, R. Nixon, E. Fossum, R. Panicacci and B. Mansoorian, "Active-Pixel-Sensor Digital Camera on a Single Chip", NASA Tech Briefs issue, vol. 22 No. 10, Oct 1998.

KEYWORDS: detector arrays; cameras; quantum efficiency; high frequency response; satellite tracking

MDA 03-074 TITLE: Superlattice Materials for Very Long Wavelength Infrared Detectors

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: MDA/SS

OBJECTIVE: Research and development of innovative growth techniques and designs for semiconductor superlattices with narrow bandgaps

DESCRIPTION: The Air Force and The Missile Defense Agency require new concepts for very long wavelength infrared (VLWIR) detectors with increased operating temperature (>40K), and improved detectivity for space based applications. These detectors will be required to operate at wavelengths beyond 15 micrometers. The presently available detectors are based on extrinsic silicon. Due to excessive dark current, the operating temperature of these detectors is below 20K. Detectors with increased operating temperatures with equivalent or better detectivity will have significantly reduced launch costs due to reductions in the weight of the cryocooler. The principal alternatives to extrinsic silicon at present are compound semiconductor superlattices based on III-V elements, such as antimonides and arsenides, or II-IV elements, such as tellurides. This task seeks to develop improved and innovative epitaxial materials and growth techniques for growing superlattices based on novel semiconductor alloy combinations such as InGaSb/InAs, HgTe/CdTe or other promising materials. The key growth issues to be addressed are the interface abruptness and repeated control of the individual superlattice layers, materials composition, doping and thickness control. Key material issues are background carrier concentration and defect structure. Key design issues are optimized choices of superlattice layer compositions and thick nesses to achieve narrow band gaps with high IR absorption and low noise currents. Characterization of the superlattice electrical, optical or physical properties is also a major factor. Both molecular beam epitaxy (MBE) and metal organic chemical vapor deposition (MOCVD) will be considered as well as other novel growth techniques. Growth on novel substrates is encouraged.

PHASE I: Phase I will address growth and design of superlattices along with the minimum characterization to demonstrate narrow bandgaps were achieved. A deliverable of a representative test sample to the government is encouraged.

PHASE II: Phase II will optimize the growth process and design demonstrated in Phase I with more extensive characterization and modeling as appropriate. Growth and evaluation of superlattice structures suitable for VLWIR detectors will be used to demonstrate the success of the program. Delivery of test materials to the government for evaluation is encouraged.

PHASE III: Phase III will develop and demonstrate prototype focal plane arrays with extensive focal plane test and evaluation as appropriate. Teaming with industrial focal plane suppliers is encouraged.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Structures based on semiconductor superlattices have applications in a wide variety of electronic and opto-electronic areas. Key devices with commercial markets would be room temperature operating infrared detectors, infrared lasers and microwave transistors. The technical product from this effort is expected to be high quality, hetrostructure epitaxial materials. The commercial product cans either be wafers of these materials designed to user needs, or devices fabricated from these materials.

References:
1. J. L. Johnson, L. A. Samoska, A. C. Gossard, J. L. Merz, M. D. M. Jack, G. R. Chapman, B. A. Baumgratza, et al, Journal of Applied Physics Vol. 80, pg. 1116 (1996).

2. C.A. Hoffman, J. R. Meyer, R.J. Bartoli, X. Chu, J. P. Faurie, L. R. Ram-Mohan, H. Xie, Journal of Vacuum Science & Technology Vol. A8, pg. 1200 (1990).

KEYWORDS: Superlattice; semiconductor materials; narrow band gap; band structure engineering; infrared detector, very long wavelength infrared

MDA 03-075 TITLE: Materials for Optical Data Handling

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: MDA/SS

OBJECTIVE: To investigate and develop innovative photonic materials that enable high performance photonic devices such as optical modulators and routers as well as for enabling the fabrication of integrated optical circuits. Innovative material solutions are encouraged that can lead to higher performance devices. Examples include electro-optic nanocomposites, DNA-based optical polymers, and new techniques for enhancing the response of commercially available materials.

DESCRIPTION: Compared with electronic approaches, photonics offers significantly advanced performance with high bandwidths for data transfer, significantly reduced susceptibility from electro-magnetic pulse interference, reduced radar cross-section, and reduced electro-magnetic noise generation. For illustration, photonics enables satellite-to-satellite and satellite-to-aircraft data links with transfer rates exceeding 100 Gbits/second, it provides straightforward solutions to data fusion, and the photonic control of phased-array radar is expected to result in a simpler architecture with reduced power and weight. However, commercially available devices are performance limited. High operating voltages, insufficiently high frequency response, high optical insertion loss, and intolerance to space radiation, for example, limit lithium niobate modulators. Since the material properties determine the fundamental performance of photonic devices, improved materials are needed.

PHASE I: The objective is to demonstrate the processing of the material and sufficiently characterize the material to predict ultimate performance.

PHASE II: The objective is to further develop, scale-up and standardize the synthesis and processing techniques. Materials will be thoroughly characterized, and photonic devices will demonstrate the material's performance.

Phase III: Design and build prototype devices such as high performance optical modulators.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Materials technology is fundamental to all applications, military and commercial. Examples of commercial applications are optical switches for cable TV, optical phase shifters for phased array radar, optical interconnects for electronic packages, and switching networks for optical communications.

References:
Hunsperger, R.G., Integrated Optics: Theory and Technology, 2nd ed., Springer-Verlag, New York, 1985.
Yariv, A., Quantum Electronics, 2nd ed., John Wiley & Sons, New York, 1975.
Hummel, Rolf E., Electronic Properties of Materials, 2nd ed., Springer-Verlag, New York, 1985.
Yariv, A., Optical Electronics, 3rd ed., Holt, Rinehart & Winston, New York, 1975.
Special Edition: Organic and Polymeric Nonlinear Optical Materials, JOSA B, Vol 15, No 1, 1998.
www.pbglinks.com

KEYWORDS: optical modulators, optical waveguides, photonics

MDA 03-076 TITLE: Coatings for MercCadTelluride

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: MDA/SS

OBJECTIVE: To develop radiation hardness coating improvements for Mercury Cadmium Telluride

DESCRIPTION: Anti-reflection coatings experience shortened useful life when exposed to solarization. Coatings species with greater bond strength and higher purity levels need to be developed so that long-term useful life of exposed LWIR sensor systems can be maintained. New graded coatings technologies also offer the potential for high optical quality with controlled physical properties capability.

Phase I: Develop two candidate compositions compatible with mercury cadmium telluride. Develop the coating process parameters and coat two samples each for characterization/concept demonstration. Characterize the purity of coated samples, and subject coated samples to adherence testing in the range of room temperature to 40 K.

Phase II: Optimize the processes for coatings of Phase I. Further characterize purity levels and coating adherence of optimized compositions.
Demonstrate resistance to radiation damage to 1 megarad. Downselect to the best candidate.

Phase III: Demonstrate full size coated sample appropriate for infrared detector applications in outer space environments.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Coatings improvements are applicable to toughened anti-reflection use for visible and infrared optics, including transparencies, as well as Eximer lasers.

References: none

Key words: Radiation Damage, Mercury Cadmium Telluride, IR Detectors, Anti-Reflection Coatings

KEYWORDS:

MDA 03-077 TITLE: Cloud Background Clutter Suppression for Early Detection and Track

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: MDA/TE

OBJECTIVE: Demonstrate the performance advantages of an efficient robust cloud-clutter rejection filter algorithm for early space-based detection and tracking of a threat missile launch based on dynamic simulation of the missile signature and trajectory against a structured cloud background.

DESCRIPTION: Space-based optical sensors for early detection and tracking of a missile launch must operate against highly-structured cloud solar backgrounds. Clutter-rejection algorithms for high probability of detection and low probability of false alarm must be demonstrated through simulation for a spanning range of environmental conditions, viewing geometries, and sensor parameters. Key elements of the simulation include background reference imagery data, model-based image projection, and sensor/algorithm dynamic response.

Phase I: Conceptualize an end-to-end scene-generation procedure for cloud solar background spectral imagery. Demonstrate the feasibility of background clutter suppression for early detection and tracking of a missile launch.

Phase II: Use multi-band image data from aircraft/satellite platforms combined with physical models for data analysis and exploitation to characterize the earth/cloud background spatial/spectral structure as a function of solar/sensor position. Generate dynamic engagement simulations of missile launches viewed against structured backgrounds by an orbiting optical sensor with ranked-order filter for clutter suppression and target recognition. Demonstrate the performance of a local maximum filter in terms of probability of detection and false-alarm.

Phase III: Use the tools and procedures demonstrated in Phase I to determine the efficacy of local maximum filters for early boost detection and tracking parameterized by sensor footprint/bandpass, target spectral intensity, cloud scene structure, solar/sensor angles, and platform motion/jitter. Quantify the impact on time after launch for detection and track.

PRIVATE SECTOR COMMERCIALIZATION POTENTIAL: The exploitation of remote-sensing spectral-imagery data supports numerous military and civilian applications for detection, identification, evaluation, and remediation.

References:
1. Wilburn, J.B., Theory of Ranked-Order Filters with Applications to Feature Extraction and Interpretive Transforms, Advances in Imaging and Electron Physics, ed. P. Hawkes, Harcourt-Brace Academic Press, 112, pp 233-332, 2000.
2. Wilburn, J.B., Developments in Generalized Ranked-Order Filters, Journal of the Optical Society of America A (JOSA A), 15, pp 1084-1099, 1998.

KEYWORDS: cloud backgrounds; solar reflection; optical imagery; scene generation; sensor algorithm; clutter rejection

MDA 03-078 TITLE: Missile Plume Radar Attenuation and Cross Section

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: MDA/TE

OBJECTIVE: Develop a modern simulation tool to predict RF interactions (attenuation, diffraction, reflection, Doppler, and backscatter) with missile exhaust plumes. The plume electrical properties are provided by a separate flowfield code.

DESCRIPTION: Missile exhaust plumes are weakly ionized plasmas that attenuate, scatter, refract, diffract and reflect RF wavelength radiation. The electron source is usually due to trace amounts of easily ionizable species such as sodium and potassium. Particulate species such as soot and metal oxide particles can also be present. The class of flows of interest are usually turbulent and highly nonuniform. Existing simulations are deficient in several respects. Specific examples include: 1) contribution of diffraction to attenuation 2) presence of caustics in refracted path, 3) attenuation/phase statistics for strong turbulence. Reliable simulations are required that address these issues.

Applications include detection, tracking, typing, discrimination and diagnostics of missile plumes. The radar cross section/attenuation-flowfield simulation combination must provide predictions of the following effects: propellant composition, velocity, altitude, aspect and radar frequency. Coherent and incoherent features are to be predicted as well as the Doppler return.

Phase I: Develop one or more methodologies that are applicable to prediction of attenuation and reflection from a highly nonuniform turbulent plasma. Provide an implementation plan to develop a software tool exploiting one or more of these methodologies.

Phase II: Implement the methodology(ies) identified and demonstrated in Phase I. The product is a software tool exploiting modern coding language and methods. The code will take the flowfield plasma description from existing and new 2D/3D flowfield simulations. The code will be validated and demonstrated against both analytical models and selected experimental measurements. Documentation of the methodology, code and validation/demonstrations will be delivered.

Phase III: This simulation capability is directly applicable to multiple DoD programs (AF, Army, MDA, Navy) that observe missile launches and reentry events with radars. This capability will be applied to selected programs for both simulation and data exploitation purposes.

PRIVATE SECTOR COMMERCIAL POTENTIAL: It is a routine launch procedure to track by radar missile launches and to communicate between the missile and launch facilities during boost. The proposed tool will improve simulations of these tracking and communication channels for commercial as well as Government Agency/DoD launches. The physical models and innovative prediction techniques developed during this program are directly applicable to other plasma environments such as the ionosphere and plasma sheaths.

References:
1. JANNAF Handbook, Rocket Exhaust Plume Technology, Chapter 4, Plume Electromagnetic Interactions, CPIA Pub. 263, Apr 1977.
2. Sutton, E.A., Plume Attenuated Radar Cross Section Code PARCS 2.0. Air Force Research Laboratory, AFMC, Edwards AFB, CA 93524, AFRL-PR-ED-TR-1998-0002.

KEYWORDS: radar; plasma; cross section; attenuation; refraction; diffraction; Doppler

MDA 03-079 TITLE: Missile Plume Temporal Intensity Fluctuation Exploitation

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: MDA/TE

OBJECTIVE: Provide a description of missile plume visible-IR intensity fluctuations. Simulate the observed temporally resolved intensities for domestic and foreign missiles under a wide range of observational conditions to evaluate temporal features for detection, track, and discrimination purposes.

DESCRIPTION: Temporally resolved passive measurements of missile exhaust plume intensity show distinct features throughout all spectral bands. The features are of two types: 1) discrete tones, and 2) a continuum of frequencies that decays with frequency at a rate depending on missile size and spectral band. The first category is attributed to combustion chamber resonance. The second category is the phenomena of interest and is identified with turbulence. Turbulent fluctuations provide a robust temporal feature suitable to separate target signature from background. New sensors now collect images at high frame rates (10 kHz) that allow exploitation of this phenomenon.

Phase I: Use selected measurements to represent the magnitude, frequency and spectral dependence of missile plume turbulent fluctuations. Develop a methodology to provide a data-driven model of plume fluctuations applicable to a variety of missile systems.

Phase II: Implement the methodology of the data-driven model into a signature simulation. Utilize newly evolving flow and signature codes to provide the mean flow on which the fluctuations are superposed. Exploit evolving flow and signature code capabilities to predict temporal phenomena when available. Demonstrate the methodology to replicate observed geometry, propellant, altitude, velocity, and aspect angle dependence. Exploit the intensity fluctuations to extract signal from clutter as observed from a remote sensor. The emphasis is on weak target signals (due to attenuation or long range) in a cluttered background. Provide detection requirements such as platform stability, sensor footprint, frame rate, and sensitivity to extract a weak fluctuation signal from background clutter. Develop an end-to-end simulation for the purpose of evaluating detection algorithms. Deliver the documentation, software and validation/demonstrations.

Phase III: Apply this simulation to selected DoD programs. A specific candidate is MDA Boost Phase Intercept.

PRIVATE SECTOR COMMERCIAL POTENTIAL: High frequency temporal signals contain a wealth of information about the observed phenomenon. Commercial remote sensing for pollution monitoring, process control and homeland defense are potential applications.

References: Simmons, F.S. Rocket Exhaust Plume Phenomenology, AIAA, Reston, VA, 2000

KEYWORDS: intensity; fluctuations; infrared, turbulence; plumes; detection

MDA 03-080 TITLE: <u>Propulsion Related Missile Phenomena</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: MDA/TE

OBJECTIVE: Characterize the battlespace optical environment due to missile operations from launch through reentry.

DESCRIPTION: Missile operations post burnout during each stage generate physical flowfield phenomena and radiative effects whose spectral, spatial, and temporal characteristics can be observed by space-based optical sensors. These observations can be exploited to derive metric or other information provided that the phenomena and effects are proximate to the missile position. Conversely, non-local phenomena can interfere with the intended observation and degrade the derived information. Methods are sought to quantify and circumvent (or exploit) non-local phenomena and effects due to propulsion related events. This phenomena includes persistent trails/extended plumes, propellant venting of fuel and/or oxidizer, liquid propellant tank ruptures, thrust termination, solid rocket motor booster segmentation, insulation/liner ejection, and missile debris. The methods to predict this phenomena should use multidisciplinary physics-based flowfield and chemistry models that produce output compatible with existing government sponsored radiation transport models for optical and radar signature generation. Combined results shall be validated against data as a basis for dynamic simulation of the phenomena and observables throughout the missile flight. The simulation would support multiple missions such as surveillance, detection, tracking, typing, targeting, and kill-assessment for space/air/ground-based sensor systems.

Phase I: Conceptualize a complete physics-based flowfield model and prototype simulation for a liquid propellant vent Show quantitative consistency between the simulated and measured spectral/spatial/temporal characteristics for different events and conditions.

Phase II Develop and demonstrate a validated comprehensive end-to-end dynamic simulation tool for propulsion related flowfield phenomena from launch through reentry. Provide a generalized simulation capability to support multiple missions and systems. Documentation of the methodology, code and validation/demonstrations will be delivered.

Phase III: Use the simulation tool to support military and civilian applications through delivered software and/or diagnostic analysis.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The spatial/temporal characteristics of extended phenomena depend on the atmospheric interaction and dispersion. The reactive dispersive characteristics of the atmosphere control the evolution and dilution of contaminants and pollutants on both local and global scales. These issues are of concern to all business sectors: military, civilian, and commercial.

References: Simmons, FS, "Rocket Exhaust Plume Phenomenology", The Aerospace Press, El Segundo, CA, 2000

KEYWORDS: battlespace environment; optical signature; non-local phenomena; dynamic simulation; model validation; atmospheric dispersion

MDA 03-081 TITLE: Hardware-in-the-loop Test Technologies

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: MDA/TE

OBJECTIVE: To develop and demonstrate new and innovative technologies for hardware-in-the-loop (HWIL) testing of kinetic energy weapons.

DESCRIPTION: Hardware-in-the-loop (HWIL) testing is used to demonstrate advanced guidance and control systems used on new missile defense systems. A significant hurdle that a HWIL facility must overcome is to provide closed-loop stimulation to weapon sensors so that they respond as they would during flight. Sensors that are typically tested include missile seekers, inertial measurement sensors, GPS receivers, and data links. Technologies are of interest that significantly advance the state-of-the-art of current HWIL test technologies. Areas of emphasis include infrared, visible, and ultraviolet projector systems and high frequency flight motion simulators. Projector systems that increase dynamic range, increase pixel resolution, and increase frame rate are required. Flight motion simulator concepts that meet requirements for cryogenic testing, simulation of airframe vibration, or address control complexities of hybrid large travel high frequency systems, are of interest.

Phase I: During Phase I, demonstration technology feasibility through modeling and simulation and/or limited hardware demonstration.

Phase II: Detailed design of a prototype system and manufacture for demonstration that the concept meets critical design goals.

Phase III: Design refinement and limited production for government HWIL test facilities

PRIVATE SECTOR COMMERCIAL POTENTIAL: The private sector will benefit from enhanced capability to test sensor systems required to operate with high accuracy in extreme environments.

References:
1. B. E. Cole, R. E. Higashi, et al., “High-Speed Large-Area Pixels Compatible With 200-Hz Frame Rates,” Proceedings of SPIE, Vol. 4366, Pgs. 121-129 , April 2001
2. New HWIL Motion System Developments, J. M. Carter, SPIE Aerosense 2001 Orlando, Technologies for Synthetic Environments: Hardware-in-the-Loop testing VI, Volume 4366, Pgs. 194-203.
3. High Frequency Motion Simulator, R. Peterson, SPIE Aerosense 2001 Orlando, Technologies for Synthetic Environments: Hardware-in-the-Loop testing VI, Volume 4366, Pgs. 225-238.
4. Image Stabilization Testbed (ISTAT), E. H. Anderson, et al., SPIE Aerosense 2001 Orlando, Technologies for Synthetic Environments: Hardware-in-the-Loop testing VI, Volume 4366, Pgs. 215-224.

KEYWORDS: hardware-in-the-loop, seeker testing, scene projection, flight motion simulators, scene generation, kinetic energy weapon

MDA 03-082 TITLE: Soot Formation in Liquid Hydrocarbon and Amine Fuel Combustion

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Weapons

ACQUISITION PROGRAM: MDA/TE

OBJECTIVE: Provide a rigorous physical model and practical computation tool for soot production and depletion due to engine combustion and plume afterburning of a liquid hydrocarbon fuel.

DESCRIPTION: Thermal emission from carbon soot is an important component of the missile plume optical signature for a liquid hydrocarbon and amine fuels. The requirement is for a rigorous physical model that describes the actual mechanisms of soot production and depletion during engine combustion and plume afterburning. The model would be incorporated in a practical computation tool that simulates the soot plume emission spectrum and spectral image as a function of missile altitude.

Phase I: Demonstrate the feasibility of the essential elements of the physical model and computation tool.

Phase II: Demonstrate and validate an end-to-end simulation tool for soot formation, depletion, and emission during missile boost. Documentation of the methodology, code and validation/demonstrations will be delivered.

Phase III: Use the simulation tool to support military and civilian applications through delivered software and diagnostic analyses.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The reduction/elimination of soot as a byproduct of engine combustion offers major potential benefits for propulsive efficiency, plume visibility, environmental impact, and economic competitiveness.

References:
1. Blake, TR, “Theoretical Study of Burning Carbon Particles”, Combustion and Flame 36:139-169, 1979.
2. Glassman, Irvin “Soot Formation in Combustion Processes”, 22nd Symposium (International) on Combustion, The Combustion Institute, 1988, pp. 295-311.

KEYWORDS: soot; combustion; afterburning; hydrocarbon; emission; signature

MDA 03-083 TITLE: Unified Passive and Active Target Signature Simulation

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: MDA/TE

OBJECTIVE: Develop and implement a unified passive VIS-IR, laser, and radar target signature simulation. The unification will include both the target geometry and material properties as well as the seamless selection of appropriate passive/active signature prediction methods.

DESCRIPTION: Current target signature predictions are made with separate simulation tools and different descriptions of the target body for each class of sensor: passive IR/EO, laser, and radar. In spite of the different level of detail required for the target description and the different methodologies for the signature prediction (different wavelength/target dimension ratios, coherency issues and polarization) there are common requirements. It would be a great simplification, labor savings, and reduced source of error to have a unified signature code, applicable to a wide range of sensing wavelengths and active/passive detection. A unified capability would also directly support multi-sensor fusion simulations.

Phase I: Identify and demonstrate feasibility of the extent to which passive/active signature predictions can be unified. Include both the target description and signature prediction methodology. Develop and demonstrate the means of providing the appropriate resolution for the target description for each wavelength region from common target data. Identify the different signature prediction methods for each wavelength region and develop a plan to seamlessly select the appropriate method. Provide a plan for a unified, end-to-end passive/active signature simulation. Provide plans and criteria for validation.

Phase II: Implement the simulation plan to provide a unified passive/active signature simulation software package. To the extent possible, provide a single software tool that can simulate passive/active target signatures over a wide spectral extent from a single specification of the target features. Clearly identify the conditions for which the simulation is valid. Validate and demonstrate the capabilities of the unified code against predictions from specialized tools. Provide complete documentation of the methodologies, unifying concepts, validation, demonstration and software.

Phase III: This software tool has application across all DoD programs in which target signature simulations are performed. This new capability will be applied to selected programs where multiple sensors (passive/active) are a key component.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Numerous commercial programs rely on multiple sensors. For example, remote sensing utilizes passive and active sensing of geophysical features. Visual/radar observations of ground and air vehicles are routine.

References:

1. Wolfe, W.L., and Zissis, G.J. (Ed) The Infrared Handbook, ERIM, Ann Arbor, MI, 1978
2. MacFarland, S.B., et.al. "Laser Cross Section Handbook", Signature Technology Directorate, WPAFB, Ohio, WRDC-TR-89-9010, vol. 1, 1990 (AD-B150-680)
3. Skolnik, M.I. (Ed) Radar Handbook, McGraw-Hill, N.Y., 1970

KEYWORDS: signature; passive; laser; radar; target; fusion

MDA 03-084 TITLE: Missile Plume Signature Transient Events

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: MDA/TE

OBJECTIVE: To develop and demonstrate new and innovative software to predict transient events observed during a missile in flight during its boost phase.

DESCRIPTION: Current engineering plume signature prediction tools are quasi-steady state and were not developed to predict the transient events observed for boosting missiles in flight. Transient events of interest include missile staging including heat transfer and associated applied forces, chuffing due to unburnt propellant, liquid injection thrust vector control, nozzle gimballing, plume impingement, as well as other various unsteady fluctuations.

Phase I: Conceptualize a methodology to predict plume unsteady fluctuations using either physics based flowfield models or empirically derived correlations coupled with existing plume signature radiation transport models. Demonstrate qualitative agreement from at least one existing plume data set available from the MDA sponsored Advanced Missile Signature Center (AMSC).

Phase II: Design, develop, and implement empirically or physics based models for the various missile plume transient events of interest. Validate the models against transient plume signature data available from the AMSC. Deliverables will include developed software user documentation, code development and validation against existing data.

Phase III: These models have applications across all DoD and many commercial programs requiring plume modeling of transient events. For example, the ability to evaluate the robustness and performance of plume-to-hardbody handover algorithms against missile staging events and plume fluctuations is required. This capability is required for simulations used in Hardware-in-the-Loop testing. These models can also provide block upgrade capability to the Battlespace Environments and Signatures Toolkit program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The private sector will benefit from enhanced capability to test sensor systems required to operate with transient plume signatures. Provides design tool to commercial launch companies to analyze plume forces and heating effects on spent stages.

References: Simmons, FS, "Rocket Exhaust Plume Phenomenology", The Aerospace Press, El Segundo, CA, 2000

KEYWORDS: exhaust plumes, missile staging, transient events, flowfields

MDA 03-085 TITLE: Laser Attenuation and Backscatter from Missile Plumes

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: MDA/TE

OBJECTIVE: Develop a modern, object oriented and parallelized simulation tool to predict laser interactions (attenuation, Doppler spectra, and backscatter) with missile exhaust plumes. Existing commercial or government flowfield models will provide plume properties such as temperature, pressure, and specie concentrations.

DESCRIPTION: Missile exhaust plumes can attenuate and/or backscatter active laser energy from missile defense systems using lasers such as the Airborne Laser. In some cases, the backscattered energy from the plume can compete with the missile hardbody potentially creating discrimination and pointing errors. In addition, the plume can attenuate laser energy degrading the communication links between launcher platforms and interceptors. This requires an accurate tool to predict these laser interactions in both a single-line-of sight mode as well as for sensor systems that collect laser backscattered spatial images.

Phase I: Conceptualize for a single altitude a laser plume backscatter line-of-sight and full image model from a solid rocket motor. Provide a detailed plan for developing a laser attenuation, backscatter, and Doppler model accounting for both absorption and scattering in amine, hydrocarbon, and solid rocket fueled motors. Investigate liquid droplets as potential scatters.

Phase II: Develop a physics based model that can predict plume laser attenuation and backscatter for plumes at altitudes from sea-level to space. The simulation tool must be capable of predicting single lines-of-sight for a simple single element detector and for multi-pixel focal plane arrays. Spectral capability should extend from the ultraviolet through the infrared. Code validation should leverage existing data sets available at the Advanced Missile Signature Center (AMSC). Documentation detailing the code development, application, and validation should be completed.

Phase III: These models have applications across all DoD programs such as Airbone Laser and candidate Kinetic Energy Boost Phase Interceptor Concepts. For example, the ability to evaluate the robustness and performance of plume-to-hardbody handover algorithms using active lasing techniques is required. This capability is required for simulations used in Hardware-in-the-Loop testing. These models can also provide block upgrade capability to the MDA's Battlespace Environments and Signatures Toolkit program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The private sector will benefit from enhanced capability to test sensor systems required to operate using active lasing techniques.

References: Simmons, FS, "Rocket Exhaust Plume Phenomenology", The Aerospace Press, El Segundo, CA, 2000

KEYWORDS: active signatures, plumes, images, lasers, radiation transport, turbulence, attenuation, backscatter

MDA 03-086 TITLE: Plume Induced Missile Body Heating

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: MDA/TE

OBJECTIVE: Determine the impact of plume induced body heating on missile target signatures. If it determined the impact is large, then develop a physics based tool or heat transfer correlation to include plume induced body heating effects in target hardbody signatures.

DESCRIPTION: Current hardbody target signature prediction capabilities do not account for potential heating of the body due to the plume as a function of flight. This can lead to an under prediction of target signatures impacting the development of plume-to-hardbody handover discrimination algorithms.

Phase I: Perform initial path finding calculations to determine the plume induced body heating effects at various altitudes of a missile in flight. Examine the target signatures differences for with and with out plume induced body heating. If of significance, prepare an integrated plan to develop a methodology to include the heating effects in target hardbody signature calculations. In addition, investigate other hardbody heating contributors such as the engine and nozzle (both external and internal).

Phase II: Develop a physics based model or correlation that can predict plume body heating effects for both liquid and solid propellant missile systems as a function of altitude. Include effects due to engine heat sink and nozzle heating versus time. Documentation detailing the code development, application, and validation should be completed.

Phase III: These models have applications across all DoD programs such as Airbone Laser, Ground Based and Sea-based Interceptors as well as candidate Kinetic Energy Boost Phase Interceptor Concepts. For example, the ability to evaluate the robustness and performance of plume-to-hardbody handover algorithms and unitary reentry intercepts is required. This capability is required for simulations used in Hardware-in-the-Loop testing for all scenarios using passive sensors for interceptor events during boost, midcourse and reentry. These models can also provide block upgrade capability to the MDA's Battlespace Environments and Signatures Toolkit program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The private sector will benefit from enhanced capability to test sensor systems required to operate using passive techniques. Also prvies improved capability for base heating effects for commercial space launch vehicles.

References: Simmons, FS, "Rocket Exhaust Plume Phenomenology", The Aerospace Press, El Segundo, CA, 2000

KEYWORDS: plumes, base heating, plume induced body heating, flowfields, heat transfer, propulsion

MDA 03-087 TITLE: Advanced Divert and Attitude Control

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: MDA/TH

OBJECTIVE: The objective of this research and development effort is to develop component technologies which will enhance the capability of divert and attitude control systems(DACS).

DESCRIPTION: Improved DACS technology is needed to address insensitive munitions and safety requirements, while maximizing the kill vehicle (KV) divert capability and/or reducing the KV weight within restricted geometries. A host of interrelated technologies include low cost/high performance nozzle materials, non-toxic and gel propellants, alternative pressurization schemes, etc. are of interest. Numerous candidates for fit, form and functional component replacements may be available in time to support a near term insertion opportunities.

PHASE I: Conduct experimental and analytical efforts to demonstrate proof-of-principle of the proposed technology to enhance DACS performance.

PHASE II: Demonstrate feasibility and engineering scale-up of proposed technology; identify and address technological hurdles. Demonstrate applicability to both selected military and commercial applications.

PHASE III: The developed technology has direct insertion potential into Theater missile defense systems such as THAAD, and GMD concepts such as multiple miniature kill vehicle (MMKV).

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would be anticipated to have applicability to commercial space platforms, as well as extension to solid-propellant gas generators used in automotive air bags.

REFERENCES:
1. S. Scheider, “High Temperature Thruster Technology for Spacecraft Propulsion,” IAF Paper 91-254, presented at 42nd IAF Congress, Montreal, Canada, Oct. 1991.
2. P. Hill, and C. Peterson, Mechanics and Thermodynamics of Propulsion, Second Edition, Addison Wesley, 1992.
3. G. Sutton, and Oscar Biblarz, Rocket Propulsion Elements, Seventh Edition, Wiley Interscience, 2001.

KEYWORDS: interceptor kill vehicle, divert and attitude control, nozzle materials, propellant.

MDA 03-088 TITLE: Advanced Seeker Technologies

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: MDA/TH

OBJECTIVE: Develop advanced sensors and supporting technologies to support multiband (IR and Visible) imagery for target detection and discrimination. This encompasses advanced window designs, multicolor infrared (IR) focal plane arrays, and imaging LADARs.

DESCRIPTION: Advanced seekers are required to provide for enhanced target detection, on-board discrimination and improved end-game guidance for hit-to-kill interceptors used in missile defense systems. These on-board sensors must be compatible with the existing hardware. The specific technology areas to be investigated are advanced window designs, multicolor focal plane arrays (FPA), and Range-Resolved Doppler Imaging LADAR capabilities.

The optical windows used on a kill vehicle (KV) must be ruggedized to withstand the operational environment of the kill vehicle. The research tasks are to develop an optical window(s) that will provide extended MWIR, LWIR, LADAR, and multicolor sensor operation in a highly stressing environment. There is a need for a near-term replacement for the existing sapphire window used for extended MWIR sensors with a longer-term need for the full optical range.

The multicolor FPA sensor technology is to develop a single FPA design that will provide two, or more, colors at full resolution to replace the multiple FPAs currently required for multicolor optical seekers. The FPA should have MWIR/LWIR capability and provide good pixel-to-pixel uniformity and low readout noise while delivering a high quantum efficiency. There is also a need to develop a multicolor VLWIR FPA with similar performance.

The combination of a Range-Resolved Doppler Imaging LADAR with a multicolor IR seeker provides a three-dimensional imaging capability that will reduce or eliminate dependency on a priori data for target aimpoint selection. Technologies that enhance the beam quality, pulse repetition rate, efficiency and power of the LADAR are critical to the optimal performance of this technology.

PHASE I: Design, fabricate and provide proof-of-principle demonstrations of advanced seeker sensor technologies.

PHASE II: Develop prototype seeker systems and demonstrate these in a simulated flight environment. These tests should include environmental testing to ensure reliable operation in a stressing, realistic operational environment.

PHASE III: Integrate seeker technology into interceptor designs for incorporation in block upgrades.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: The sensor technologies being developed in this effort will have dual application in law enforcement and for material processing to detect material defects.

KEYWORDS: Seeker, Multicolor Focal Plane Array, LADAR, MWIR, LWIR, VLWIR

MDA 03-089 TITLE: Advanced Avionics

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: MDA/TH

OBJECTIVE: The objective of this research and development effort is to develop innovative high performance avionics that will enhance the capability of interceptor seekers, flight computer and guidance sensors.

DESCRIPTION: The term “advanced avionics” represents a broad category of technology, generally taken to include the seeker, flight computer, and guidance sensors-Inertial Measurement Unit(IMU), Global Positioning System(GPS), etc. Improvements to the EMD avionics processing architecture are required to enable advanced seeker image processing, data compression and sensor fusion algorithms, while maintaining or reducing weight and power dissipation. The development of an advanced avionics architecture could yield fit, form and functional component upgrades to support the next generation THAAD upgrades. Small, extremely sensitive, with high dynamic range accelerometers that is impervious to sock and vibration is needed. As the interceptor seekers migrate toward a strapdown seeker/IMU systems operating under a more powerful propulsion system avionic components that are insensitive to sock and vibration will be needed. High density electronic technologies are also desirable, such as packaging technologies that allows silicon to be “stacked” in order to exploit 3-D volumetric packaging without adding circuit boards.

PHASE I: Conduct experimental and analytical efforts to demonstrate proof-of-principle of the proposed technology to enhance avionics performance.

PHASE II: Demonstrate feasibility and engineering scale-up of proposed technology; identify and address technological hurdles. Demonstrate applicability to both selected military and commercial applications.

PHASE III: The developed technology has direct insertion potential into Theater missile defense systems such as THAAD, and GMD concepts.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would have applicability to automobile industry, communication satellites, and at the computer industry.

REFERENCES:
1. J. Soderkvist, "Micromachined Gyroscopes" 7th ICSS Sensors Actua., pp.638-41, 1994.
2. H.Helvajian, "Microengineering Aerospace Systems" The Aerospace Press, American Institute of Aeronautics and Astronautics, 1999.

KEYWORDS: interceptor, avionics, accelerometer, electronics.

MDA 03-090 TITLE: Advanced Battery Technology

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: MDA/TH

OBJECTIVE: The objective of this research and development effort is to improve battery performance and design by identifying new electrochemistry or improve existing electrochemical systems and components, or improving packaging, in order to increase specific energy and/or specific power beyond what is currently available, preferably at an equal or lower cost.

DESCRIPTION: Improvements in battery technology are needed to accommodate advanced interceptor power requirements, enable advanced electronic packaging approaches, and reduce cost. Advances in all facets of missile technology have resulted in smaller, lighter components and ultimately smaller missiles. Despite this decrease in overall size however, power and energy requirements are increasing. Emerging system designs are pushing the envelope of current battery electrochemistry. The challenge systems engineers face is one of balancing power requirements with overall size and weight limitations. Additionally, the battery is oftentimes the last component considered during system engineering when available space and weight is extremely limited. There are two possible approaches to addressing this critical issue. One approach is to investigate alternative electrochemistry options that are capable of providing more power and energy per unit weight/volume. A second approach is to identify improvement opportunities within existing electrochemical systems/components that would increase overall battery efficiency. In terms of the Ragone curve that represents battery performance, the desired result is to move those curves up and to the right.

Current battery technology is generally limited to single-use applications, is relatively inefficient, and is generally packaged in a cylindrical container, limiting the electronics packaging options available to the designer. High efficiency, multiple-use, arbitrarily shaped batteries could be a solution to this design constraint. Two approaches might be considered here. One is to efficiently force the electrolyte into odd-shaped corners and efficiently extract charge/current. The other is to reconceptualize the entire design by developing a power source that might be integrated into the KV structure itself - something that could occupy all the wasted space between and around subsystems, etc. Constraints would include total mass and total energy storage consistent with current thermal and/or chemical batteries (something like 1-2 kg mass and 150,000 W-s).

PHASE I: Demonstrate the feasibility that an innovative research and development approach can address the critical need for improvement in battery specific energy, specific powe or novel packaging concepts.

PHASE II: Develop proof-of-concept components and/or prototype demonstrations for the approach defined in Phase I.

PHASE III: Integrate the technology into ballistic missile applications through full qualification programs.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would have extremely limited commercial application due to its special purpose nature for military applications.

KEYWORDS: battery, electrochemistry, power, energy, Ragone.

MDA 03-091 TITLE: Safe and Arm and Arm and Fire Devices

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: MDA/TH

OBJECTIVE: The objective of this research and development effort is to develop a millimeter size propulsion safe and arm and arm fire device.

DESCRIPTION: An Arm Fire (AF) device is a safety device that provides electrical and mechanical interruption of an ignition train in order to prevent the unintended functioning of a missile's rocket motor. These devices are used to prevent accidental or inadvertent ignition of rocket motors during flight or in any usage which could cause an extreme hazard to personnel or facilities. AF devices incorporate a fail-safe mechanism that enables the device to remain armed only while power is applied. When power is removed from the device, they return to the safe position.

A Safe and Arm (S&A) device is a safety device which can be fail-safe or which can incorporate a latching mechanism which enables the device to remain armed after power is removed and can be typically be returned to safe position by applying power. Latching S&A devices are commonly used to initiate system destruct in the event of a test failure. Fail-safe S&A devices are typically used for launch vehicle initiation and for rocket motor stage separation during flight. S&A devices commonly use an Explosive Train (ET) to transfer energy to another device from the S&A.

S&A and AF devices are essential elements of today's complex launch vehicles, missiles and weapons systems. These devices must be compact, highly reliable and satisfy stringent performance requirements. Using traditional manufacturing methods, current S&A devices are precision electromechanical systems that are typically 4 inches by 4 inches by 3 inches and weigh 3.7 pounds. Today's advanced S&A designs are 2.25 inches by 2.25 inches by 2 inches and weigh 1.25 pounds. An innovative design for S&A and AF devices that is based on MEMS (micro-electromechanical systems) propulsion technology could reduce the size by a factor of ten and reduce the weight to grams.

The application of MEMS technology to S&A and AF devices holds great promise in attaining substantial reductions in the size, weight, volume, parts count and cost. These improvements potentially offer orders of magnitude improvements over existing S&A/AF designs. MEMS technology has matured to the state where compact and reliable S&A/AF device designs can be created using well established and demonstrated MEMS manufacturing processes. Furthermore, these MEMS systems can be designed, built, tested and flight qualified using existing MEMS design and manufacturing methods and fabrication infrastructures.

PHASE I: Conduct a study which establishes and quantifies the performance and advantages of MEMS S&A and AF devices, performs trade analysis studies among design alternatives, delivers preliminary conceptual designs of both S&A and AF devices as well as manufacturing plans for both to assure manufacturability.

PHASE II: Demonstrate feasibility and engineering scale-up of proposed technology; identify and address technological hurdles. Demonstrate applicability to both selected military and commercial applications.

PHASE III: Build actual flight devices that will be subjected to a rigorous test and qualification.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Launch vehicles, Air Bags initiators, Microthrusters, and MEMS Switches.

KEYWORDS: Safe and Arm, Arm and Fire, MEMS

MDA 03-092 TITLE: Solid Rocket Motor Propellant Inspection Device

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: MDA/TH

OBJECTIVE: The objective of this research and development effort is to develop a portable and accurate means of detecting defects in solid rocket propellants.

DESCRIPTION: A significant shortfall in all Solid Rocket Motor Development programs is our inability to verify accurately solid rocket motor propellant structural behavior and failure predictions on a subscale motor test level under severe thermal and ignition pressurization conditions prior to firing full-up, expensive solid rocket motors. In today's success oriented programs, full scale solid rocket motor test failures carry a significant penalty to any program office or element from a cost, schedule and political point of view. Consequently, this SBIR topic is focused on development of an automated, nondestructive, non-contact tool to measure solid rocket motor bore strains at cold (-50C) and hot (+60C) tactical storage extremes as well as under combined temperature and gas pressurization conditions (2000 to 5000 psig) for subscale solid rocket motor testing. This non-intrusive, non-contact technology should be capable of measuring accurately and precisely the displacements of a solid rocket motor bore surface as a function of time, temperature, and motor pressure at each longitudinal and circumferential location in order to determine and record the onset of propellant grain failure (solid propellant grain cracking). Moreover, this temperature and pressure insensitive tool should be easily portable to bring out to the field or depot to conduct surveillance inspections. This feature alone will yield the Ballistic Missile Defense System (BMDS) millions of dollars in cost avoidance with respect to current solid rocket motor development programs and future Rocket Motor Limited Life Component Programs. A portable Computer Data Acquisition System that uses a software code employing an easy to use Graphical User Interface (GUI) should accompany this portable tool to track and record all data on a common test time scale.

PHASE I: Conduct experimental efforts to demonstrate proof-of-principle of the proposed technology to detect and characterize defects in simulated propellant. Assess the initial feasibility of packaging the sensing and data acquisition system into a field portable system.

PHASE II: Demonstrate feasibility and engineering scale-up of proposed technology; identify and address technological hurdles. Demonstrate applicability to both selected military and commercial applications.

PHASE III: The cost avoidance realized by the Ballistic Missile Defense System (BMDS) and the services by employing this technology at the various depots and missile assembly, integration and test facilities would be significant (> $100M) by virtue of eliminating missed defects in these materials prior to shipment of test missiles for flight testing and/or missiles for eventual deployment. Hence, the anticipated Phase III program customers would include a wide range of current interceptor programs.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would be anticipated to have a high level of interest in Non-destructive Evaluation of explosives, commercial launch rocket propellants, and solid-propellant gas generators (SPGG's) used in automotive airbags.

REFERENCES:
1. P. Marteau, F. Adar, and N. Zanier-Szydolski, "Application of Remote Raman Measurements to the Monitoring and Control of Chemical Processes," American Laboratory, pp.21H-21Q, Oct. 1996.
2. L. Burnett D. McKay, E. Magnuson, and E. VanderHeiden, "Solid Rocket Motor NDE Using Nuclear Magnetic Resonance," Review of Progress in Quantitative Nondestructive Evaluation 12, 663, 1993.
3. P. Rizo, M. Antonakios, and P. Lamarque, "Solid Rocket Motor Nondestructive Examination Using Tomosynthesis Methods", 14th WCNDT, New Delhi, India, 1996.
4. M. Antonakios, and P. Rizo, "Real Time Tomosynthesis System Applied to Solid Rocket Motor Examination," Proceedings of the 7th European Conference on Non-Destructive Testing, 26-29 May 1998,

KEYWORDS: Non-destructive evaluation, solid rocket propellant, health monitoring.

MDA 03-093 TITLE: Fiber Optic Communication Ribbon

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: MDA/TH

OBJECTIVE: The objective of this research and development effort is to develop a lightweight, high bandwidth fiber optic communications ribbon for missile applications.

DESCRIPTION: A major emphasis in all missile technology development is miniaturization and mass reduction. One particular area of missile hardware where achieving these goals has been problematic is the electrical cabling used for avionics interpackage communication. More specifically, traditional communication design techniques between missile front end packages and missile aft end packages require large/lengthy conduits and covers that run down the length of the propulsion system such as a solid rocket motor to house wire bundles. Unfortunately, this adds tremendous inert weight to the missile that in turn reduces the missile propulsion efficiency and increases missile aerodynamic drag. Therefore, mission battle space/foot-print and missile iso-timeline performance is also penalized. In addition, although perceived many times to be "low risk", wire bundles/cables have historically caused or contributed to a significant percentage of missile reliability problems and higher than expected development costs. Consequently, this SBIR topic is focused on development of a low cost, reliable advanced fiber optic cable ribbon with miniaturized transmitter and receiver connectors that can be processed and imbedded in a composite pressure vessel structure such as composite solid rocket motor case. This fiber optic communication ribbon must be immune from RF and IR signal interference, lightweight including connectors, provides inherent nuclear shielding and capable of handling 100X the current communication bus bandwidth demand over traditional copper cable bundles used in missile systems. The eventual demonstration test series will cover high speed communication through this embedded fiber optic ribbon cable during composite case pressurization and bending at temperature extremes ranging from –50C to +60C. The implementation of this technology would dramatically reduce missile integration steps and production/assembly costs, and greatly enhance missile reliability and testability by completely eliminating communication conduits and conduit covers to protect traditional copper wire bundles. The cost avoidance realized by the Ballistic Missile Defense System (BMDS) by employing this technology in future missile system upgrades would easily add up to 100 + million dollars during the life cycle stages of development, production and depot maintenance of the missile system.

PHASE I: Conduct experimental efforts to demonstrate proof-of-principle of the proposed fiber optic ribbon technology.

PHASE II: Demonstrate feasibility and engineering scale-up of proposed technology; identify and address technological hurdles. Demonstrate applicability to both selected military and commercial applications.

PHASE III: Conduct engineering and manufacturing development, test and evaluation, and hardware qualification.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would be anticipated to have a high level of interest in commercial and civilian launch markets.

REFERENCES: None

KEYWORDS: Fiber Optics, missile avionics, communication.

MDA 03-094 TITLE: Structural Flaw Detection in Composites

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: MDA/TH

OBJECTIVE: The objective of this research and development effort is to develop a portable and accurate means of detecting flaws in composite materials.

DESCRIPTION: Low-weight/high strength composite materials offer many desirable properties and benefits in advanced systems (i.e., graphite motor cases, composite over-wrapped pressure vessels) and Ceramic Matrix Composite (CMC) structures such as Carbon-Silicon-Carbide braided nozzles. A shortfall in the utilization of composite materials in critical, high-value systems (including missile integration, assembly and test quality assurance programs) is the difficulty with current methods to detect structural damage or flaws within structures made from such materials, on a highly reliable and consistent basis. Moreover, a portable yet high-resolution non-destructive evaluation tool or system to determine damage within these structural components at the depot level or in the field is critically needed. Existing methods are often difficult to transfer to a field portable instrument. Consequently, this SBIR topic is focused on development of a portable non-destructive evaluation system that is capable of detecting cracks/flaws within both composite and CMC structures on a non-intrusive basis without having to initiate missile disassembly. This technology should have the capability to accurately detect, track and record all flaw data (number, size, flaw orientation and flaw location) over the temperature range of –50C to +60C. Consideration would also be given to safe in-situ health monitoring technologies with field portable monitoring systems.

PHASE I: Conduct experimental efforts to demonstrate proof-of-principle of the proposed technology to detect and characterize defects in composite materials. Demonstrate the initial feasibility of packaging the sensing and data acquisition system into a field portable system.

PHASE II: Demonstrate feasibility and engineering scale-up of proposed technology; identify and address technological hurdles. Demonstrate applicability to both selected military and commercial applications.

PHASE III: Conduct engineering and development, test and evaluation, and hardware qualification.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would be anticipated to have a high level of interest in Non-destructive Evaluation of composite structures and components including commercial aerospace, automotive, civil infrastructure (composite or composite reinforced bridges and overpasses), and sporting goods manufacture.

REFERENCES:
1. B. Hoskin, A. Baker, Composite Materials for Aircraft Structures, AIAA Education Series, New York, 1986.
2. M. Bartlett, "Testing Sports Rackets," Advanced Materials & Processes, p.53, Vol. 158, No. 5, Nov. 2000.
3. D. Guo, A. Mal, and K. Ono, "Wave Theory of Acoustic Emission in Composite Laminates," J. Acoust. Emission, Vol. 14, pp. 519-546, 1996.
4. A. Kumar, S. Beard, and D. Deason, "Development of SMART Layer Technology for Health Monitoring of Structures," Proceedings, National Space & Missile Materials Symposium, Monterey CA, June 2001.

KEYWORDS: Non-destructive evaluation, advanced materials, polymer- matrix-composites, ceramic-matrix-composites.

MDA 03-095 TITLE: Development of Advanced Radar Technologies for Missile Defense

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: MDA/TH

OBJECTIVE: Identify, develop, and demonstrate advances in phased array radar technologies that will support existing Missile Defense (MD), and other, radar system architectures and will enable revolutionary radar performance and cost enhancements to future radar architectures.

DESCRIPTION: The MD radar threats envisioned for the near- and far-term are a challenging mixture of countermeasures that include chaff, jamming, low observable RVs, balloons, coatings, anti-simulation, and simulation, among other countermeasures, that will require novel approaches to the discrimination problem. This phased array radar technology research effort is focused on technologies to defeat evolving threats (to include advanced Electronic Counter Measures (ECM), maneuvering and reduced signature reentry vehicles while operating in a nuclear environment), by developing technologies that support improved performance capability, transportability, supportability, reliability, availability, and system survivability. This effort covers a wide spectrum of potential technologies. Key areas of research include advanced, lightweight antennas; wideband, multichannel, multimode digital receiver/exciters; and ultra-wideband/multiband signal/data processing technologies.

Advanced, light weight, antennas that demonstrate a two-fold reduction in both cost and volume while demonstrating a sensitivity improvement of 4-10 times and a 4-8 time improvement in the operating bandwidth are needed. Such an antenna should include the use of lightweight materials, transportable/ erectable antenna structures for achieving a large antenna aperture in small stowed volume, and multi-aperture transmit and receive coherence technologies for transportable, distributed apertures.

Antenna technologies also include those technologies to achieve long time delay (true time delay) functionality in a very small, lightweight, and low-cost MMIC package, supporting ultra-wide instantaneous bandwidth applications, at subarray or element level and electronic protection technologies (e.g., adaptive digital beamforming, adaptive processing, etc.) for large bandwidth, multiple frequency, multiple waveform (beyond traditional LFM/stretch wideband waveforms) processing.

Wideband, mulitichannel, multimode Digital Receiver/Exciter (DREX) technologies are needed that can produce a 10-30dB dynamic range improvement, a 2-4 time instantaneous bandwidth improvement, and improved phase/amplitude control). These technologies should move the digital interface closer to aperture, thereby eliminating costly, bulky and sensitive analog electronics. They should use open architecture technologies to enable plug-and-play of building blocks to realize different receiver configurations and support for diverse RF applications. Finally, they should be capable of multiple waveform generation and processing capabilities beyond traditional LFM/stretch waveforms.

Ultra-wideband/multiband signal/data processing technologies and concepts are needed to increase discrimination k-factor by 2-4 times and decrease the vulnerability to RF countermeasures. This includes Multiband (MB), Ultra-wideband (UWB), and Synthetic Ultra-wideband (S-UWB) discrimination technologies to provide 2-8 times increase in the available instantaneous and total operational bandwidths.

PHASE I: Analyze, design, and conduct proof-of-principle demonstrations of advanced radar technologies that are scalable to desired missile defense radar system requirements.

PHASE II: Develop and demonstrate prototype radar technologies which meet or exceed missile defense requirements. Conduct hardware and/or software tests to evaluate the performance of the technology in a realistic environment. Prepare detailed plans to implement demonstrated capabilities on critical military and/or commercial applications.

PHASE III: Integrate radar technologies into missile defense systems and demonstrate enhanced performance in realistic environments.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: Private sector applications exist for advanced radar technologies throughout commercial industries. Commercial radars, communications equipment, and other portable systems will have dual use potential for this development.

KEYWORDS: Sensor, Radar, Signal Processing, T/R Modules, Phased Arrays , Receiver/Exciter, Discrimination, Countermeasures, Fusion

MDA 03-096 TITLE: Operation in Stressing Environments

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: MDA/TH

OBJECTIVE: Identify, develop, and demonstrate advanced techniques to protect missile defense radars, communication devices, and other electronic systems from hostile or co-site radio frequency (RF) and electromagnetic (EM) energy while minimizing the additional weight and cost of the protection.

DESCRIPTION: The incorporation of modern microelectronics into military radar, communication, and sensor systems lowers their threshold for damage from RF and EM sources. Effects of RF and EM radiation can be mitigated through limiters and shielding. While there has been some research on new shielding technologies, significant improvements, shielding techniques still rely on heavy, metallic EM enclosures for protecting sensitive systems. New coatings that can be applied to lightweight enclosures or directly on populated circuit boards are being sought that cover the frequency range from 100 kHz to 100 GHz. Shielding that increases the potential for nuclear survivability are also of interest.

In addition to shielding systems from radiation, the front end of receivers must also be protected using a limiter or similar device. State-of-the-art front-end limiters fall into two categories: 1) very fast, high voltage limiters that are heavy and incompatible with solid state electronics and 2) very small, compact limiters that have limited power handling capabilities. A new class of limiter is needed sub-nanosecond response times and that can reflect up to 10 kilowatts of RF power with very low insertion losses. These limiters are needed in the 10 MHz to 100 GHz frequency band, with primary emphasis in the 1 to 10 GHz region.

It is unlikely that a single technology can effectively mitigate across this span of application, but solutions are desired that can mitigate RF effects over the broadest possible bands. While the primary focus of this effort is to protect radar front-end electronics, these limiter technologies will also be applicable to communications equipment and COTS electronics, such as computers. All mitigation techniques proposed must be applicable to Commercial Off The Shelf (COTS) electronics. Because of the potential need to retrofit existing systems, the techniques must be low-cost and applicable to a wide variety of electronic systems.

PHASE I: Analyze, design, and conduct proof-of-principle demonstrations of practical techniques to protect military electronics from high-power external RF emissions.

PHASE II: Develop prototype protection devices and conduct tests to evaluate the performance of protection devices and protected equipment in challenging RF environments. Prepare detailed plans to implement demonstrated capabilities on critical military and commercial applications.

PHASE III: Apply mitigation techniques to critical military system(s) and demonstrate enhanced survivability in realistic environment.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: Dual applications exist for RF mitigation technologies with the commercial electronics industry. The RF environment that commercial radars, communications equipment, and other electronics are exposed to is becoming increasingly severe. The technologies developed through this research program will provide protection of both military and commercial electronics from both accidental and deliberate threats.

REFERENCES: [1] Kikel, A., et. al.; Plasma Limiters. AIAA paper AIAA-98-2564. 1998

KEYWORDS: Radio Frequency Mitigation, Electromagnetic Interference, Shielding, Limiters

MDA 03-097 TITLE: Integrated Data Compression and Security Algorithms

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: MDA/TH

OBJECTIVE: The objective of this research and development effort is to develop improved data compression and security algorithms and techniques. Integration of these advanced algorithms would allow increased data flow among the weapon system elements in a secured manner leading to more efficient processing of mission critical information.

DESCRIPTION: The state of the art algorithms used for data compression and security are not adequate to meet existing Theater Missile Defense (TMD) needs. While NSA approved encryption algorithms exist, they need to be integrated with advanced data compression techniques to fully address TMD needs. Application of these technology advancements to the TMD domain would enable an increased interceptor telemetry capability, including real time seeker FPA data, and ultimately enhance battlefield learning opportunities. Secure, high-speed information flow among the weapon system elements would improve system responsiveness, while precluding the compromise of critical technologies following accidental loss or capture. Algorithms could be developed, integrated, and validated in time to support a near term insertion opportunity.

PHASE I: Conduct experimental efforts to demonstrate proof-of-principle of the proposed algorithm technology to compress relevant TMD data in a secure environment. Demonstrate the initial feasibility of integrating the algorithms into an existing system.

PHASE II: Demonstrate feasibility and engineering scale-up of proposed technology; identify and address technological hurdles. Demonstrate applicability to both selected military and commercial applications.

PHASE III: Integrate algorithms into TMD systems and demonstrate the total capability of the updated system.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The data compression and security algorithms have commercial applicability in applications where content-rich data is required to be transferred in a secure manner to ensure data integrity. Specific private sector areas with significant commercial potential include the electronic commerce and wireless transmissions industries.

REFERENCES:
1. J.S. Przemieniecki, Critical Technologies for National Defense, AIAA Education Series, Washington, D.C., 1991.
2. David Salomon, Data Compression, The Complete Reference, Springer, New York, 2000.

KEYWORDS: data compression, security, algorithms, data, information technology, data loss, data processing, data integrity

MDA 03-098 TITLE: Robust Discrimination of Ballistic Targets

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: MDA/TH

OBJECTIVE: Identify, develop, and demonstrate advanced and innovative sensor techniques to improve the performance and affordability for discrimination of ballistic missile threats in increasingly complex countermeasures environments

DESCRIPTION: Advances in key sensor technologies can greatly increase the potential ability to perform robust, high-confidence discrimination on ballistic missile reentry vehicles. These critical technologies include:

· Globally accurate timing to provide the ability to control timing/coherence, and hence phase angle, accurately over long periods of time and over large regions of space. Precise timing enables the capability to operate coherent, multi-static, and ultra-wideband sensing systems that are supported by ultra-wideband communications.

· Advanced computing capability to provide inexpensive, rugged, reliable high-speed processors and large-scale memory components. These digital systems will allow work performed by expensive special purpose electronics to be performed by general-purpose electronics controlled by special-purpose software. These hardware and software characteristics support the ability to field and maintain high-performance military systems much more affordably than in the recent past.

· Precision fabrication and manufacturing to provide the capability to manufacture very high performance analog electrical components as well as optical/RF components of sensors, such as lens and wave-guides, at reasonable costs.

These three key technologies can be exploited to produce dramatic improvements in night vision devices and other tactical systems and they have the potential to advance ballistic missile discrimination and missile defense sensing by leveraging modern integrated manufacturing technologies

Technology innovations sought should allow for the synthesis, design, and demonstration of discrimination systems that exploit modern component technologies to provide discrimination products that are flexible, robust, effective, producible, and less expensive to maintain and upgrade than the current discrimination techniques. These approaches may have some or all of the following characteristics:

- Multi-static and multi-sensor configurations,
- Ultra-wideband over multi-wavelength spectra,
- Lightweight (especially the antennas)
- Highly integrated,
- Coherent, adaptive operation of ensembles of sensors,
- Extensive use of COTS parts and assemblies.

Phase I: Analyze, design, and conduct proof-of-principle demonstrations of advanced sensor hardware discrimination technology to improve the discrimination of ballistic missile and cruise-missile threats using techniques selected by MDA.

Phase II: Develop and demonstrate brassboard prototype sensor systems to demonstrate performance and implementation feasibility (in hardware) of candidate techniques.

Phase III: Apply discrimination techniques to deployable prototype sensor systems suitable for field demonstrations.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: Applications that exist for inexpensive, lightweight, discrimination systems include air traffic control applications, medical applications to differentiate changes in tissues.

KEYWORDS: Discrimination, Target Recognition, COTS, Lightweight, Affordable

MDA 03-099 TITLE: Electronic Hardening

TECHNOLOGY AREAS: Sensors, Electronics, Weapons

ACQUISITION PROGRAM: MDA/TH

OBJECTIVE: The objective of this research and development effort is to develop innovative electronic hardening concepts and technologies for current and next generation avionics for application to THAAD and theater/terminal missile defense (TMD) systems.

DESCRIPTION: Missile seekers and avionics will be required to perform their missions at higher levels of detection sensitivity, with improved discrimination capability, at longer acquisition ranges. All this should be able to function reliably in a wide variety of environments, particularly the hostile environment of space and nuclear weapon radiation (including prompt and persistent gamma, single event effects, total ionizing dose, etc.) and a battlefield/storage environment (Shock, vibrations, thermal, etc). Current designs rely on Commercial-Of-the-Shelf (COTS) technology. This has been migrating toward increasingly smaller silicon feature sizes (close to 0.1 micron and lower, and with lower operating voltages). Also, many applications involve MEMS technology. Today, sophisticated weapons rely on faster computers and greater memory capacity. The hardened electronic sytems that can survive under such adverse conditions are mission critical. For lightweight systems shielding may not be practical although innovative shielding approaches could be applicable. Nevertheless, inherently radiation-resistant component, systems, and usage techniques are imperative.

PHASE I: Conduct research and experimental efforts to demonstrate proof-of-principle of the proposed concepts. Determine feasibility of automated radiation hardened design tools, in conjunction with the rad hard foundries, to make system electronics designs, including commercial designs, portable among foundries.

PHASE II: Demonstrate feasibility of proposed concept/technology; identify and address technological hurdles; Finalize Phase I design and develop a prototype component. Demonstrate applicability to both selected military and commercial applications.

PHASE III: Due to current high levels of interest of this technology in both government and industry related to ground and space based applications, there are many opportunities for the advancement of this technology during phase III program. Partnership with traditional DOD prime-contractors will be pursued since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Supporting instruments can be used in a wide variety of commercial environmental/remote sensing monitoring systems and Space surveillance, weather satellites.

REFERENCES:
F.T.Brady, J.Maimon, and M.Hurt "A Scalable, Radiation Hardened Shallow Trench Isolation," IEEE Transactions on Nuclear Science December 1999.
R.C.Lacoe, J.V.Osborn, D.C.Mayer, S. Witczak, S.Brown, R.Robertson, and D.R. Hunt, "Total-Dose Tolerance of Chartered Semiconductor 0.35 mm CMOS Process," IEEE Transactions on Nuclear Science December 1999.

KEYWORDS: Transient radiation, mitigation, Photo-detectors, In-pixel, FPA, Simulation, miniaturize, sensors, Proton, Neutron, single event effects, hardened electronics, hardened MEMS.

MDA 03-100 TITLE: Lightweight Energy Production and Storage

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: MDA/AC

OBJECTIVE: Develop improved lightweight, high energy density, energy storage technologies to supplement primary power systems in high altitude airships (HAA).

DESCRIPTION: Improved lightweight renewable energy storage is needed to supplement the primary power systems for HAAs in order to sustain long-term flights. Technologies must be able to support HAA stationkeeping and operation at 70,000 feet for one continuous year or more. Environmental factors encountered at an altitude of 70,000 ft. must be considered when developing energy storage. Candidate technologies will likely support nighttime operations (up to 16 hours, cycled one time per day), with power drawn during daytime hours from photovoltaics or other energy sources. A host of interrelated technologies, including, but limited to, fuel cells and rechargeable battery arrays, are of interest. Components must accommodate high current draw and require no maintenance. New technologies and improvements to existing technologies (e.g. life-expanding or performance-enhancing technologies for existing designs) will be considered.

Desirable Power System and Storage Characteristics include:
- Solar arrays:200-400 volts, 500 kw, 15-20% effieient
- Electrolyzers: Generate 1500-1800 SCF of Hydrogen in 16 hours.
- Fuel Cells: Generate 600-900 KW-hrs for 16 hours.

PHASE I: Conduct feasibility studies, technical analysis and simulation, or small-scale proof-of-concept studies, according to proposed innovations and improvements. Throughput, life-cycle response, temperature response, and other performance properties should be considered and measured, where applicable.

PHASE II: Implement technology assessed in Phase I effort. Phase II effort should include demonstration of power storage capabilities, combination of components to provide additional power, and integration with power systems with high current draw and cycling characteristics similar to those required to sustain a HAA for several hours. Full testing and verification of performance properties should be included.

PHASE III: The contractor shall finalize the technology of the lightweight energy storage and begin commercialization of the product.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would advance renewable energy technologies, with application in a spectrum of areas, in both the government and private sectors.

KEYWORDS: energy storage, renewable energy, fuel cell stack, rechargeable battery, regenerable power, high altitude airship

MDA 03-101 TITLE: Propulsion and Propeller Technology for High Altitude Airships (HAA)

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: MDA/AC

OBJECTIVE: Improve existing means for controlling large airship movement in a high altitude, low air density environment.

DESCRIPTION: Efficient, lightweight, propulsion is needed for stationkeeping and point-to-point maneuvering of HAAs at approximately 70,000 ft. Desirable advances include development of very large, very lightweight propellers or alternate efficient, propulsion concepts. Winds at this altitude average near 20-40 knots most of the time. However, significant wind spikes of 100 knots are observed occasionally. The airship propulsion system must require no maintenance for a period of continuous operation over one year, have a mean time between failure of at least one year, and be able to accommodate both cases using the minimum amount of power possible, while keeping the airship on station as accurately as possible. Specific considerations include efficiency, maximum thrust, performance over time, mean time between failure, and number of moving parts. Technological innovations related to new propulsion concepts and propeller fabrication will be considered.

PHASE I: For new propulsion concepts, conduct design analyses and a thorough trade study of available or soon to be available electric propulsion technologies and capabilities, as related to HAA needs, and prepare a report on those findings. The study should enumerate advantages and risks related to performance, efficiency, mean time between failure, potential for future improvement with technology, and other criteria. For propeller concepts, the Phase I effort should include a design and simulation study, along with a materials study, which should also detail improvements over current technologies. The Phase I effort may also include small-scale experimentation and testing of candidate materials and designs, to the degree allowed by time and cost restraints.

PHASE II: The Phase II effort should concentrate on realization of the efforts begun in Phase I. This effort would include implementation of a new propulsion concept or full development and testing of new propeller designs.

PHASE III: The contractor shall finalize technical improvements and begin commercialization of the product.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would benefit commercial platforms using electric propulsion in a low air density environment, such as commercial communications airship platforms.

References:
1. Khoury, A. and J. David Gillett, ed. Airship Technology, The Airship Association, Cambridge University Press, New York (1999): http://www.airship.demon.co.uk/Technology.html
2. AIAA-83-0190 Design of Optimum Propellers, Adkins, et al
3. Calculation of the Propulsive Efficiency for Airships with Stern Thruster - AIAA 14 LTA Tech Convention, July 2001

4. NASA CR 194455 Effect of Power System Technology...Anthony Colozza
5. NASA TM-1998-206637 Design and Performance Calculations of a Propeller for Very High Altitude Flight ...L Danielle Koch
6. NASA CR-1998-208520 High Altitude Propeller Design and Analysis Overview...Anthony Colozza

KEYWORDS: propulsion, high altitude airship, propeller

MDA 03-102 TITLE: Long-Endurance, Autonomous Vehicle Control

TECHNOLOGY AREAS: Air Platform, Information Systems

ACQUISITION PROGRAM: MDA/AC

OBJECTIVE: Develop or adapt existing autonomous vehicle control for long-term, sustained remote operation and stationkeeping of high altitude airships (HAA).

DESCRIPTION: A vehicle control system that can accommodate long-term autonomous stationkeeping and maneuvering is needed for HAAs. Current technologies lack the mitigation of error accumulation needed for long-endurance missions that may require keeping a vehicle on station for one year or more. Desirable technological innovations will enable very long-term autonomous operation at 70,000 feet altitude that may include stationkeeping, point-to-point maneuvering, or both.

PHASE I: Develop a preliminary design and identify potential components and key algorithm performance requirements. Conduct a preliminary analysis to show system configuration, performance, applicability to HAA requirements, as well as cost benefits. Design strategies should incorporate COTS components, where possible. Analyses should delineate primary technical challenges and establish risk mitigation strategies.

PHASE II: The Phase II effort should entail implementation of the Phase I concept analysis. Tasks shall include, but not be limited to, algorithm development and implementation, full testing, including simulation of error analysis, profiling of error accumulation over time and under a variety of anticipated conditions expected for the HAA, and a detailed demonstration of system performance. A detailed performance analysis of the technology demonstration is required.

PHASE III: The contractor shall finalize the technical aspects of the system and begin commercialization of the product.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Technologies developed under this SBIR would benefit high altitude communications platforms by enabling platforms to operate autonomously for longer periods of time.

REFERENCES: E. GAI, "Guidance Navigation, and Control from Instrumentation to Information Management," Journal of Guidance, Control, and Dynamics, V.19(#1), pp.10-14, Jan-Feb 1996.

KEYWORDS: controls, remote, autonomous, guidance, navigation, GN&C, long-endurance, high altitude airship